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THE UNION AND CONSOLIDATION OF A FRACTURE.

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"When we speak of Wolff's law we really mean the law of osteoblasts."[1]

"The law is simply this: *osteoblasts at all times build and unbuild according to the stresses to which they are subjected.*"[1]

So writes Sir Arthur Keith, Hunterian Professor of the Royal College of Surgeons, England, in his profound and charming book, "Menders of the Maimed."

There is perhaps something to be added to the law pronounced by Wolff and crystallised by Keith. For beyond the mechanical function of the bone, beyond the service of strut to weight and lever to muscle, there is another factor determining the life and work of a bone cell. We may call it heredity, or ancestral habit with Samuel Butler.[2] For the clan of cells native to any bone will build it in a form near to the normal even in a limb which has never borne weight and, paralysed from birth, has never felt the strain of muscle pull.

A bone is like a honey comb, but the analogy would be closer if a bee lived and worked in every cell. The bone cells belong to the building trade, their life is construction, and they live "over the shop." Disuse of the bone means a slack time in the trade, active construction lessens, and decalcification, a process always present in living bone, predominates. Persistent unemployment means that only a skeleton staff is kept at work looking after the permanent (hereditary) structure. The faculty which Butler calls ancestral habit or inherited memory provides the necessary stimulus. Bone building is the first duty of a bone cell, but some form of stimulus must be frequently applied or he quickly grows lazy. He never works unless he is convinced of the necessity. "Stress is as necessary for their health and activity as exercise is for the living body."[3] But their tasks must be within their power, in magnitude, in period, and in frequency, or they will be overworked and damaged, for overstrain is as harmful as exercise is healthy. It implies an upset relation between strength and stress: feeble strength and normal stress, or normal strength and exceptional strain. The rickety bone or the "unsound" callus will bend under the normal weight of the body superimposed too often or too long. A bone decalcified by disease, disuse or deranged metabolism breaks under ordinary strain; but the normal bone is broken only for forces excessive in amount or exceptional in direction.

We can persuade the cells to increase the strength of any bone by subjecting it to repeated strains beyond the normal yet not great enough to break it; we can restore strength to a diseased bone by cure followed by exercise, and to a disused bone by use.

FRACTURE.

When a bone is broken a new state of affairs is originated. The bone cells have hitherto lived a most regular life, a life governed by habit, day after day, year after year, almost the same. Suddenly a cataclysm has occurred: numbers of cells find themselves drifting around homeless and rubbing shoulders with every sort of wandering cell. They are nourished by a congenial fluid: they have not forgotten their art: each promptly sets to work; it is as if he felt a primitive impulse toward making himself a new shell. The fracture which convulsed and scattered these bone cells has excited a great many more. It is like an accident in a tenement street where all the children and unemployed quickly collect; so from the broken ends of the bone all the young cells come rushing out.

They find a nutritious exudate of blood and lymph, and in it collects a great crowd of bone cells, fiber cells, and blood cells. "Organization" quickly begins and a coherent matrix develops.

Now out of this heterogeneous crowd of cells between and around the fractured ends arises order; governed by the intimate influences which environment wields, the bone cells thrive, and the other cells wilt, feeling themselves in a "false position." If the fragments are kept in good apposition and alignment a new piece of bone will connect them which will ultimately resemble the original bone in strength, form and structure. Under less favorable circumstances even greater natural skill is evident; for these "cunning engineers"[4] will build and buttress a bridge so adapted and constructed as to carry without risk the various forces that the cells learn by experience to expect.

Thus great is the skill of these little cells, the

descendants of countless generations of the craft. Millions of years ago their ancestors, unicellular individuals, were building each his own little calcareous house. As Keith says,

> "We must suppose that the cells which build the skeletons of vertebrate animals are the descendants of such cells and have inherited all their marvellous aptitudes."[5]

Now they have learnt cöoperation, and possibly developed even greater technical skill.

Hilton has taught us that

> "The Surgeon will be compelled to admit that he has no power to repair directly any injury."

He must

> "acknowledge in all humility that it is the prerogative of Nature alone to repair the waste of any structure. He will thus realize that his chief duty consists in ascertaining and removing those impediments which obstruct the reparative process, or thwart the efforts of Nature, and thus enable her to restore the parts to their normal condition."[6]

Our mechanical task is to provide and maintain close apposition and true alignment, to protect the organizing matrix and the young callus as it develops from disturbance, and to allow unrestricted circulation in the part.

It is well to bear in mind even at this early stage the general as well as the local causes of non-union, and particularly, by careful scrutiny of radiograms, to be on the watch for malignant disease.

After a time, which varies, manual and *x*-ray examination will tell us that the callus is ready to begin learning to look after itself. This is a process of education in all fractures but the lessons have to be most carefully supervised where the callus is to carry the weight of the body, for callus is by Nature malleable: As a result of the stimulus of the fracture the bone cells develop first a gritty matrix, then a mass of callus of indeterminate consistency, but their engineering skill awaits the guidance of stress and strain. It is only the use of certain particles of bone arranged along certain lines that ensures their persistence and further development until struts are formed; and the disuse of other particles, distributed along lines on which no force plays, that causes their absorption.

Disuse of reparative tissue brings about that state of mind described by John Hunter as "a consciousness, in the part to be absorbed, of the unfitness or impossibility of remaining under such circumstances, whatever they may be, and therefore they become ready for removal, and submit to it with ease."[7]

That consciousness as to the fitness or unfitness of remaining is not intuitive (or, as Butler would say, habitual) but is the result of lines of force acting on a delicate calcareous network of which each spicule is intimately associated with a tiny but sensitive and conscious cell. The spicule-building cells of certain sponges show in their work sensibility to vibration. So, too, in the union of our broken bones, once the indeterminate osteogenetic response to the fracture is complete, it is only where strain is repeatedly applied, perhaps as a response to vibration of its spicule, that the bone cell builds.

DELAYED UNION.

After a reasonable time there may be apparent failure of union. Again we review the patient and his fractured limb: most of all is it wise to make quite certain that the circulation of the blood at the site of fracture is in no way constricted.

> "In looking back on the ununited fractures I have seen I generally recall an attenuated limb and a thick plaster case."[8]

We must not blame the bone cells until we are sure we have given them fair treatment. Having satisfied ourselves as to the apposition, immobilization, and free circulation, we should be patient.

> "Union may be delayed; this is sometimes unavoidable, but there is a vast difference between delayed union and non-union. When union is slow, it is of great importance to leave the limb alone and not repeatedly to move the fragments to see how things are progressing."[9]

But in a few cases, the stimulus of the fracture seems to pass away, and a soft spirit of indolence descends upon the cells: osteoblasts and fibroblasts cease from the strenuous life. The lotos has been eaten. 'Why should life all labor be?' 'Let us alone.' 'We have had enough of action.'

> 'Let us swear an oath, and keep it with an equal mind,
> In the hollow Lotos-land to live and lie reclined
> On the hills like Gods together, careless of mankind.'

Thus delayed union may sometimes pass towards non-union, but it is very wise to delay before we use this term, and to remember that

> 1. "Setting aside a few cases in which there is some actual condition of disease, experience shows that nearly all cases of "non-union" are really cases of "delayed union."[10]
>
> 2. "The ununited fracture is often the result of surgical impatience. * * * Non-union would rarely occur if delayed union obtained proper attention."[11]

Our duty is clear:

> "We must endeavor to transform the indolent callus into an osteogenetic factory."[8]

For it is possible to apply persuasion to a lazy bone cell, in the convincing form of personal chastisement.

"With a heavy well covered mallet the fractured ends were beaten."[11]

"We should try to give our cells such treatment as they will find most easy to understand."[12]

Thomas was so convinced that with proper care and, when necessary, forcible persuasion, a delayed union would unite, and was so successful in treatment of obstinate cases by hammering, damming, and so on, that he only operated upon cases where the bone ends were not in contact, the only state of affairs which in his eyes seem to have constituted non-union. He tells us that his experience

* * * "enabled me to dispense entirely with interference by incision when fractures are delayed in repair, and to confine the treatment by skin incision, entirely to cases of true non-union, that is, a condition when the fractured points are not in contact."[13]

NON-UNION.

I cannot in this short paper deal with general disease and its effect on local repair nor with local bone disease. But whether there is obstinate delay or definite failure in union we must never forget Hilton's axiom, "We have no power to repair directly." No operation, not even grafting, far less plating, can unite the fracture. Union ever awaits the activity of the bone cells of the part and is achieved only by their action. This knowledge must guide us in choosing procedure if our conservative methods fail.

It is indeed possible, by plates of steel or dense heteroplastic bone fastened by screws or bolts, to bridge the gap and so to restore the mechanical function of the bone; but this is not living union, the influence of such action is definitely to delay further, and often prevent, true union, and the danger of such treatment is great.

Plating for delayed union has no reasonable basis: it provides no stimulus to osteogenesis. On the contrary, the more effective the fixation the more completely does it remove all duty, all stress and strain and exercise, from the indolent cells.

This is so clear, so self-evident, that its statement might well appear superfluous. But bones are still being plated for delayed union and non-union! So long as the patient remains in bed there is a plausible appearance of success; but when weight-bearing begins the plate pulls out or bends. I have seen many patients where this treatment had been carried out and in one or two cases even repeated; their story has been almost invariably one of many months wasted and, in the end, bitter disappointment.

AUTOPLASTIC GRAFTING.

This must be examined in the same light. It is true that Gallie and Robertson,[14] and others, have dispossessed us of the gratifying feeling that we were transplanting a piece of bone full of vigorous osteoblasts: we now know that only a small proportion of the cells in the graft survives, those within reach of the flowing lymph. But grafting by the inlay method opens up large areas of raw bone from which fresh osteoblasts pour out. Further, an autoplastic graft forms a great attraction to young osteoblasts and is a tremendous stimulus to their activity. For these purposes the best method of grafting is that which opens up wide areas of healthy bone and brings the graft itself and each bone fragment into extensive raw contact. We may safely look to Keith to round off the subject as aptly as he opened it:

'It is not Wolff's law which an orthopedic surgeon should cultivate, but a close acquaintance with the behavior of osteoblasts. If he understands them fully and treats them rightly, they can prove his most helpful friends; if he ignores them, they can and do prove obstreperous.'[1]

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FRACTURE OPERATIONS.

Gross displacement of the fragments is not in itself an indication for operative treatment. In many cases reduction by manipulation may be easily and rapidly effected; in others, with much overlapping of the fragments, extension may prove efficient. Doubtful cases should always receive the benefit of preliminary non-operative treatment, and the results should be confirmed by further radiograms. The age, occupation, and general condition of the patient must also be considered. Old age does not necessarily constitute a barrier to operation, but the risks are greater and the prospects of a good functional result (even after successful operation) are more remote. In children operation will be rarely indicated; non-operative measures yield a high percentage of success, and young bones are not well adapted to all forms of operative fixation. In general, extensive comminution will contraindicate operation.—WILLIAM PEARSON in *The Lancet*.

THE TREATMENT OF FRACTURES

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A specialist requested to write an article on "Fractures" must naturally assume that he is expected to present the subject from his peculiar angle. The title of the article should therefore be the "Orthopedic Treatment of Fractures." Such a title would very well explain what is the matter with the treatment of fractures at the present time. This is the age of slogans and standardizations, but human tendencies remain from one generation to another much the same, and today, instead of the homeopathic or allopathic dosage question, we label our yearnings for authority the "plaster treatment," or "traction and suspension" treatment, as the case may be, and proceed to cheerful villification of those whose predilections or personal idiosyncrasies do not ape our own. That is a tendency with which I am not in sympathy.

One of the current activities of the American College of Surgeons is an attempt to raise the level of the general treatment of fractures. One may legitimately assume, therefore, that the level is low. The means adopted to this end is the assembling of groups of surgeons in various localities. These local groups are to deliberate upon the various problems presented to them and submit the results of their cogitations to a general board, which will eventually therefrom produce a number of recommendations that shall thenceforth serve as standards. It is quite evident that the medico-legal aspect of this movement is important.

We may take it for granted that any person selected for membership upon a local committee of the College treats his fractures fairly well. In other words, the average of his results is satisfactory, so that he does not often suffer from the necessity of having to call others in consultation. In such an assemblage, therefore, it is amusing and instructive to hear upon a given subject, such as the treatment of Colles' fractures, diametrically opposite expressions of opinion. Such being the case, we must be driven to the conclusion that the end rather than the means is important. Instead, therefore, of getting angry as to the relative merits of, shall we say, plaster of Paris and traction-and-suspension, let us concede that competent men get favorable results by either method, and examine the causes underlying such a concession.

The treatment of fractures consists in putting the ends of a broken bone together, having restored the normal alignment as nearly as may be, and holding them together until union is sufficiently firm to permit the resumption of normal function of the bone in question.

Under such a definition several lines of demarcation at once appear. The function of the bones of the lower extremity is to bear weight, therefore a fractured femur takes longer to get well than a fractured humerus. A Pott's fracture is worse than a Colles' fracture. A broken toe is worse than a broken finger. The occupation of the patient is important. A pianist insures his fingers, a dancer her legs. The economic question must be considered, in that some patients must perforce be treated in the home rather than the hospital. One doctor may have been brought up in an orthopedic atmosphere, while another may never have been forced to treat a major fracture until the war. Upon such factors must rest the seemingly astounding variations in individual practice.

In attempting to arrive at first principles it is difficult to avoid aphorisms. If I may allow myself one it is that it is impossible to make an omelette without breaking eggs. In the fracture question, the largest egg that must be broken is the necessity for comparative immobilization of the broken fragments of bone. I say "comparative" advisedly, for I do not believe that any form of external fixation insures absolute immobilization, and even the internal fixation afforded by a Lane plate is only temporary.

In order to obtain immobilization it is necessary to fix more or less of the patient. The amount of him that must be fixed naturally depends upon the situation of the injury. It appears fairly well established that in the case of a Colles' fracture the treatment consists in reduction followed by application of molded plaster splint or plaster bandage. In practically all other fractures, however, treatment is now being advocated that confines the patient to bed, even in such injuries as the formerly despised fractured clavicle.

There are, generally speaking, three methods of treatment of a fracture now at command: immobilization by traction and suspension; immobilization by plaster of Paris or other methods of splinting; immobilization by open operation and internal fixation.

The advantages of traction and suspension are that the patient is fairly comfortable. It permits, as a rule, constant inspection and measurement of the affected part, and frequent *x*-ray examination. It permits early motion in neighboring joints, and early

massage. It should, but rarely does, mitigate the atrophy consequent upon disuse of the affected limb. The disadvantages are: it confines the patient to bed during the entire course of his treatment; it requires a sound and comprehensive knowledge of mechanical principles; it is entirely at the mercy of anyone coming in contact with the patient—doctor, nurse, orderly or visitor, and very largely at the mercy of the patient himself. I remember once being called in consultation to see a patient with a fracture of the superior lip of the acetabulum. He had been in bed with traction for three weeks. The interne in charge was dilating upon the rarity and extreme interest of the case. He said that on admission there were two inches of shortening of the limb, which was reduced by traction. He said that on removal of the weight the shortening immediately recurred. He thereupon removed the weight and the shortening recurred. just as he had said it would! This treatment must be applied and constantly supervised by experts.

The advantages of plaster of Paris are that it is completely under the control of the person who applies it. Once properly applied there is little if anything further to be done until the time comes for its removal. The greatest advantage is that unless it envelopes too much of the patient it permits him to get about on his feet or on crutches as the case may be. Patients, for example, wearing the long body spica applied for fracture of the neck of the femur can, if they desire, walk about with crutches. The muscular exercise so permitted is of much value to the circulation in the limbs, and the mental effect upon the patient is often most important, particularly in the aged. The weight of plaster is usually grossly exaggerated. A properly applied, adult, long-bodied spica including the food should not, when dry, weigh more than ten pounds.

The disadvantages of plaster are that if it is improperly applied it is useless, or positively dangerous, or so uncomfortable that it is impossible to wear. The picture of Volkmann's ischemic paralysis should be ever before one. It is almost impossible to use plaster in connection with wounds, as in war surgery. If it remains in place over long periods a varying amount of joint stiffness may ensue. Although it is the custom to speak of plaster of Paris causing atrophy of the muscles, I do not believe such a statement to be true. It is the disuse incidental to the injury that necessitates the application of the plaster that causes atrophy.

I think that practically everyone will agree that open operation should not be undertaken until conservative methods have been tried and failed, or in cases in which for one reason or another it is at once quite evident that they will be futile.

One might almost say that the most important part of the treatment of fractures is the after-treatment. There was a time when a broken wrist would be placed in splints and left there until there was no doubt that the bones must have united. What happened to soft parts, neighboring joints, etc., during that period was a matter of indifference. The splints were removed at the end of the allotted period and the patient left to himself to "work out the stiffness." It is in the reaction from such practice rather than in the evolution of new methods of treatment that contemporary improvement in treatment lies. When I was in the medical school the word "function" was rarely heard. We were taught the origin, insertion, relations, blood-and-nerve-supply of muscles, but what the muscle did was a matter of indifference. Happily such darkness no longer prevails. Patients are being regarded as patients, not as "fracture cases," and being treated with due regard to early return to their particular occupation.

Early motion and massage are extremely valuable, but their dangers far more outweigh their benefit unless they are carried out by the surgeon himself. Some masseurs are good and some are bad. After bony union is firm any massage is comparatively innocuous, but in the early stages untold harm may be done by injudicious manipulation, and if the surgeon is too busy, or too indifferent to attend to such details himself, he had best leave such cases alone. I was once asked whether or not I was afraid of "losing caste" by carrying out such treatment myself. Such a question is illuminating.

In conclusion, it appears to me that the treatment of fractures should—so far as this is possible—be undertaken only by surgeons who are personally interested in the subject, and who are equally familiar with the various methods of treatment at command. Thus they may be in a position to weigh their various advantages and disadvantages as applied to a given case, and accordingly make a wise individual selection. If there be even an excuse for the use of the term "orthopedic treatment" it would seem to me to lie in this distinction. Whereas, as I have mentioned already, there was a time when treatment consisted in immobilization of the affected part until bony union should have taken place and leaving the rest to nature, orthopedic treatment begins at the time of injury, and ceases only with the return of normal function.

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COMPRESSION LEVERAGE FRACTURES OF THE ANKLE JOINT.

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Percival Pott described a fracture of the fibula three inches above the joint with a rupture of the internal lateral ligament of the ankle, which has been described since then as a Pott's or a Dupuytren's fracture.

If the fracture described by Pott exists at all it is so extremely rare as to be negligible, the rupture of the internal lateral ligament being in evidence only in those cases showing a great outward dislocation of the foot. As can be seen from the tables here appended, such a dislocation of the foot is an extreme rarity with a high fracture of the fibula unless there is also a fracture of the internal malleolus.

The classic definition of Pott's fracture most generally accepted today is a fracture of the fibula two to four inches above the ankle joint and a fracture of the internal malleolus as well. But to limit the description of a Pott's fracture to any such close definition is to rule out most fractures at the ankle joint that are produced by exactly the same mechanics that present practically the same pathology, and that carry the same prognostic importance.

We are told that all the other fractures of the fibula at its lower end are not Pott's, because there is no breaking of the internal malleolus and no rupture of the internal lateral ligament. One could easily imagine a fracture of the fibula by a comparatively slight blow (direct violence) which would produce nothing except a bony lesion. The damage would be slight and the prognosis in such a fracture would always be good.

A man steps from a curbing, his foot strikes an uneven surface in the pathway and it turns outward. There is impact behind the force, and the weight of the man is added to the impact. The fibula breaks at the joint surface, usually, but occasionally above it, as in the classic type. The inferior tibio-fibular ligaments are stressed, always damaged; the tip of the fibula swings outward, and usually backward. There is widening of the mortise of the ankle joint and, whether or not it occurs, there is the potentiality of dislocation.

There is a great deal more damage than in the case of the direct blow, and there is a tremendous injury to the joint itself which is not present in the other case. One is ephemeral. The other is dynamic, and its effects are lasting.

There is strikingly little difference in the *x*-ray appearances to the casual observer, but the difference is there. In disagreement with many of my colleagues, if we were to cling to the old nomenclature such an injury is a Pott's fracture. If the ordinarily accepted definition is that of only one variety of the fracture and that variety one which while more severe, is less common than other types; and if by the very specificity of its wording it excludes absolutely the others, then it is clear that it has not only failed as a definition, but it is infinitely worse than this because it has befogged the whole subject.

If we classify these injuries under the terminology used in this paper, we shall be able to group them

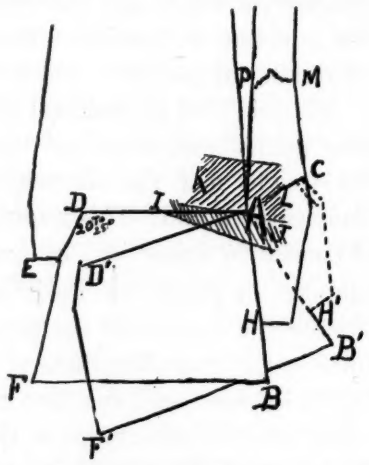

Fig. 1. A schematic representation of the movement to which is attributed by most surgeons the break of the external malleolus and the supposed rupture of the internal lateral ligament. It is clear that if point D were to drop to point D' the external malleolus would be broken, I. J., the transverse ligament would give way and oftentimes K. L. the inferior tibio-fibular ligament also. The internal lateral ligament would nearly always be ruptured. No such movement is possible. The astragalus slides over against the external malleolus to exert pressure undoubtedly, but it can not turn. The fibula breaks across A. C. and at times, as explained in the text, at P. M. because subjected to three stresses at the same time.

scientifically since etiologically there are certain mechanical features that are common to all.

First, Compression, because it is the most important feature and it is always present in every case,—the weight of the man (static compression) plus the infinitely greater compressive stress due to impact. These breaks at the ankle are not pure compression breaks; but the compression, by keeping the astragalus firmly against the tibio-fibular mortise, while at the same time causing the locking of all the tarsal articulations, determines to a great extent the character of the injury.

Second, Leverage, because there is a leverage stress in two directions with compression on one side of the breaking bone and tension upon the other.

We subdivide this into eversion and inversion, and by further subdivision we are able to group all these various types in a truly scientific manner which was never possible under the old nomenclature.

The medical profession as a whole are united on certain of the fundamental features of the production

of these fractures while differing on minor points; and they may be roughly divided into three classes.

One class believes that the fibula breaks first in eversion and is followed by a break of the internal malleolus or rupture of the internal lateral ligament; the second believes that the internal lateral ligament or the internal malleolus breaks first and this is followed by the break of the fibula; and the third class believes that the fracture in the main is produced by a rotation of the foot, but that the internal lateral ligament breaks first to be followed by the break of the fibula.

The author thinks, and in his writings he believes that he has proven, that all of these groups are wrong. That, however, is not germane to this article, and any reader who is interested in this phase of the problem is referred to the author's paper in *Surgery, Gynecology and Obstetrics*, February, 1924.

For the purpose of this present communication it is necessary only to state my position briefly: There is no turning movement of the astragalus possible in the mechanics of production of any of these fractures at the ankle joint by either eversion or inversion except in the type which in my classification is Subdivision A of Type 3, and this is a very rare combination.

The compression that is represented by the static weight of the man plus the infinitely greater stress due to impact is not only sufficient to overcome any such turning movement as is represented by figure 1, but it is also the great determining factor in the production of this injury.

The main factors that combine to make this injury a serious one is the dissemination of great compressional stress, the damage to soft parts (tendon sheaths and ligaments) and the destruction of the mortise of the ankle joint, thus rendering dislocation a possibility whether or not it occurs.

Add to this the treatment by absolute immobilization, which has been accepted by the profession since the time of Pott and which has extended oftentimes to six or seven weeks, and it is no wonder that there is disability following even the simplest of these fractures, which extends into months before the recovery of motion and which is many times permanent, when by mobilization we should have secured a normally functioning foot in a comparatively short time.

Now there are certain fundamentals of mechanics with which the surgeon should be familiar, especially in fracture work. There are several kinds of stresses that cause fracture or breakage when applied beyond the elastic limit. These are: tension, which tends to lengthen the substance under consideration; compression, tending to shorten it; transverse breaking stress, tending to bend it; sheer, tending to cause one part to slide over the adjacent part; torsion, tending to twist it.

Tension, compression, and sheer are called simple stresses.

Transverse stress is a compound of tension and compression. Tortional stress is a compound of tension and sheer.

To these might be added tearing stress, which might be either tension or sheer, but in which the resistance of different portions are brought into play

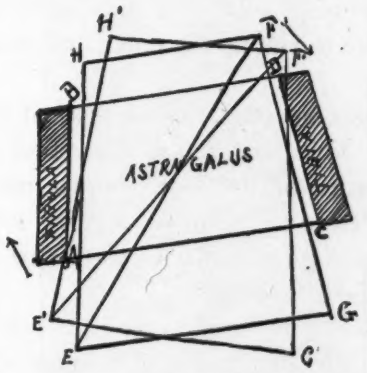

Fig. 2. A representation of the twisting or rotation stress due to the lever of rotation. The figure explains itself. Roughly speaking, a parallelogram is rotating to force its oblique distance between two rigid walls which are large enough only for one of its sides. It cannot be done, and A and D will show the pressure points and the arrows the direction of stress. Reversed, it applies to inversion as well. This is the stress which breaks the internal malleolus so often in an everting foot and the external malleolus in an inverting foot; and such breaks are made possible only because of the compression.

in detail or one after the other, instead of simultaneously as in simple stresses.

A sudden stress is more injurious than a steady or gradually applied stress.

A tension stress tends to cause rupture or separation of particles in the line of stress, but a compression stress may, depending on the material, cause it to separate into two or more wedge-shaped pieces, to bulge, or buckle, or bend or, as in granite, to fly into pieces. Old bone will sometimes do this very thing.

If to a piece of wood, for instance, we apply a transverse breaking stress, we shall find that it will always break in tension; that is the molecular structure of a fibrous material will always pull apart on the tension side first and there will be more or less long splintering.

In a crystalline substance the break will tend to be more transverse and as it approaches the compression side there will be a tendency to a split out, a wedge, because a transverse stress is always a stress in tension on one side and compression on the other.

and where compression and tension are equal, a break is always in tension.

A fracture of any one of these types at the ankle joint is a fracture under compression, but it is not usually a pure compression fracture, which we believe to be true of Colles'. It is the result of three stresses:

First, compression, static and impact.

Second, a transverse breaking stress, due to eversion against the lower portion of the fibula from within outward.

Third, a transverse breaking stress due to rotation outward and backward against the lower portion of the fibula.

These last two stresses, both transverse breaking stresses, are responsible for the tendency of the fibula fracture to run up the outer and posterior side of the bone.

There is misunderstanding because of the terminology used. One writer uses abduction to mean a turning outward of the foot, another uses *eversion* to mean the same thing, while another uses eversion to mean a turning out of the forward part of the foot pivoted on the astragalus.

I use abduction and eversion synonomously. Turning to the dictionary definitions—"evert, to turn out"; abduct, to withdraw from the body axis." Therefore the entire foot is turned outward in both cases.

The term *rotation* is used to indicate the twisting of the foot on the center of the astragalus as a pivot. Therefore, in external rotation the forward part of the foot from the center of the astragalus forward is twisted outward, and as the forward part is twisted outward the posterior part must perforce be twisted inward. The converse holds good in inversion. These two stresses are simultaneous.

A pure abduction or eversion without external rotation is a rarity. A pure adduction or inversion without internal rotation is an impossibility. So that with the compression in evidence in a stressed foot as it always is in an injury of this kind, eversion and external rotation there is the resultant of three stresses brought to bear on the lower end of the fibula and as the rotation brings the anterior external surface of the astragalus to bear on the lower end of the fibula it also brings the posterior internal articular surface of the astragalus to bear on the internal malleolus. Here is deadlock unless something breaks, but it is evident that under these conditions the internal lateral ligament can not be stressed.

Now all the stress is really against the inferior tibio-fibular ligaments and the internal malleolus, because in reality the fulcrum of both of these levers is these ligaments and if they give without fracture, as is possible but rare, there results an injury that is practically a "Pott's" without any bony fracture at all. Such a case is shown in plate 3. Usually, however, the fibula breaks and releases the pressure; the astragalus is pushed outward and dislocated, and if badly dislocated it is at this point that damage to the internal lateral ligament occurs if the internal malleolus has not been broken.

If the internal malleolus is broken by the rotational stress at the same time that the fibula breaks then no damage can occur to the internal lateral ligament, which simply pulls the internal malleolus outward with the dislocating foot.

Fig. 3. Shows eversion injury without fracture. Internal tibiofibular ligaments are ruptured. There is therefore destruction of the mortise and here there is some outward dislocation. The only case of this type in author's series.

The method of production of these fractures is pretty much the same in all. A man steps from a curbing and turns his ankle outward or inward, that is, he abducts it and externally rotates it or he adducts it and internally rotates it. Running or jumping he does the same thing. In the case of ball players he slides for a base and encounters an obstruction with his foot. Sometimes it happens in ordinary walking over rough ground, but usually there is the phenomenon of impact in most of these ankle fractures.

In eversion fractures particularly, as I have pointed out, there are two methods of production, one while the center of gravity is internal to the everting foot, and the other where the center of gravity is outside. In the second variety of stress the man is really turning on his fixed foot and the stresses are apt to be more severe and the acme of stress or the resultant of all the stresses is apt to fall higher up and result oftener in a high fracture of the fibula. But by whichever method the injury is produced the stresses are the same save in intensity, and if one

injury is to be called a Pott's fracture, so must the other.

I have pointed out how lax inferior tibio-fibular ligaments sometimes are responsible for the high break of the fibula, even where the stresses are comparatively mild, but the majority of the milder type of injuries in abduction are produced when the center of gravity is internal to the stressed foot. Out of our series of 249 cases, 55.4% were of fractures of the fibula alone, and 42.2% were clearly at the joint level, and dislocation was in only 21.01% of this number. This is the comparatively mild type, never-

Fig. 4. Most frequent type, fracture of fibula alone at joint level without dislocation or with slight dislocation.

theless, as ordinarily treated by restriction for weeks, the end-results have been quite as bad as in those showing a much more serious injury.

Why are there so few inversion injuries in comparison to the eversion? Certainly for every man who turns his foot outward, there are ten who turn it inward. Try it yourself with the weight on the foot under stress and see how easily you can give in the direction of the force with the inverting foot and how impossible it is with an everting one. In other words, the man undergoing stress in the position of inversion applies to himself the principals of jui jitsu and thus saves himself.

In the position of eversion and outward rotation all the bones of the foot are locked against shoulders of resistance and present a rigidity that is not present in inversion.

In inversion there is much more play to the tarsal articulations and this fact often saves the man from fracture. This increased latitude of motion in inversion in the face of great stress is, however, an added danger because it gives an added momentum to the stress. Backward dislocation of the foot is a far more frequent accompaniment of this type of injury.

Posterior and anterior splits of the tibia are impact phenomena primarily with eccentricity of the compressional stress as a factor. Unless the split is large, it does not usually present any great difficulty.

For the classification of these injuries the reader is referred to my article in *Surgery, Gynecology and Obstetrics,* February, 1924.

TREATMENT.

My treatment of these compression fractures of

Fig. 5. Fracture of fibula alone high up. Outward dislocation is less pronounced in this type than where the fracture is at the joint level.

the ankle is the same as that which I have advocated for all joint fractures for many years (*Annals of Surgery,* 1918-'19-'20-'21-'22) and is based on the contention that the months of disability that have followed all joint fractures have been more the result of misdirected treatment than of the injury.

Mobilization is the treatment for all joint injuries with the single exception of the entirely intracapsular fracture of the hip. Active motion should be begun at the earliest possible moment.

Reduction where there is dislocation is the important point and is usually easy of accomplishment. Even in the simple cases of fracture of the fibula, either low down, or high up, the same force that produces the break is apt to posteriorly displace the lower fibular fragment and to displace the astragalus backward a little, which is often missed in the study of the *x*-ray plate and disregarded in treatment. First, flex the knee. Rocking the foot usually suffices to correct the lateral displacement, but many of these minor posterior dislocations are not reduced.

Exert direct pressure backward on the intact tibia above, and a strong pull forward on the tuberosity of the os calcis carrying the foot into dorsal hyperflexion. So doing will save the patient much subsequent discomfort. With direct pressure, we can also correct these backwardly carried inferior fragments of the fibula and this is essential. Twist the foot inward and forward; it twisted outward and backward when the injury occurred. After reduction, there is very little tendency to displacement, unless a posterior split has occurred. If the internal malleolus

Fig. 6. Fracture of both bones at joint level.

is intact adduction is the position of choice and may be maintained by any splint. For the emergency I personally use a pillow splint tied with tapes and reinforced with pieces of splint wood or board, internal, external and posterior. Below the foot, the open ends of the pillow case are folded and pinned, so as to keep the foot hyper-dorsiflexed. If the position is satisfactory roentgenographically, we put on a Cabot splint, always bending the knee to keep the position of hyper-dorsiflexion of the foot. This relaxes the gastrocnemius and soleus, which form the tendo Achilles. A "doughnut" should be under the heel always. No Pott's fracture should be put into plaster at this time; the swelling is too great and the cast is ineffective always under these conditions. If the internal malleolus is broken, I do not invert the foot, but use a straight position. Inversion with a broken internal malleolus is an absurdity; worse than an absurdity, it is a menace.

Where the internal malleolus is broken and displaced Magnuson of Chicago makes a small incision over the malleolus and fastens it back into place with an ivory pin which he leaves. He believes that by this maneuver he restores the mortise of the joint and that then he can place the foot in the position of inversion. I believe the reduction and the straight position are sufficient in most cases, but in a very limited number, where reposition of fragments is hard to obtain this treatment is ideal.

I always have several pillows under the knee to keep it in the flexed position, thus rendering the hyper-dorsiflexion of the foot comfortable. Only in those cases showing a large anterior split of the tibia, which are rare, do I vary the hyper-dorsiflexion of the foot. Even in these cases I am careful to get the

Fig. 7. Fracture of both bones, the fibula fracture high up, a typical "Pott's."

foot above a right angle, because this is one of the movements easily lost by disuse and slow in recovery. Keep the foot above a right angle with the leg, and you will have no difficulty, even where there is a tendency to new bone formation on the anterior edge of the tibia. If there is a posterior split of the tibia, it is essential to keep the foot dorsally flexed; a plantar flexed foot is apt not only to redislocate where the fragment is large and involves at least half the articular surface of the tibia, but it is apt to push upward the posterior fragment. Fortunately, these posterior splits are usually small and do not involve a great articular surface.

I begin motion in most of these cases by the third or fourth day in the ordinary type, and certainly by the end of the first week in nearly all of them, unless there is tremendous swelling or tremendous tearing of ligaments which happens only in the very serious cases. If one observes carefully he will be surprised how rarely this occurs. Every day, thereafter, the foot is gently moved passively, the hyperflexed foot being carefully lifted from its splint by the toes, the knee kept well flexed. I follow the same

maneuver in all cases whether the fibula is broken high up or low down. The broken internal malleolus simply means a greater degree of caution. Plantar flexion must never be carried to extreme. An arc of 30° of motion at first is sufficient.

Dorsal flexion actively and strongly is essential and effort is made by the patient early to strongly dorsiflex his foot, except in those cases of anterior split. Even here, passive flexion within limits is used from the first.

In the case of posterior splits, be especially careful not to plantar flex too quickly or too far. In some few cases of great injury, I permit immobilization for 10 to 15 days with the toes free for movement, but in most cases I begin motion gently not later than the sixth day. As passive motion is to be preferred to immobilization, so active motion, no matter how limited, is to be perferred to passive motion. Motion must be retained from the first, and can be so retained in practically every case, if care and intelligence are used in the manipulation. This is the point of the whole treatment. Restriction of motion, partial ankylosis, is due to organization of inflammatory products, and involvement of tendons and tendon sheaths in the reparative scar tissue, together with a traumatic synovitis which is kept without motion. It is remarkable how quickly these ankles tend to stiffen if immobilized. It is remarkable how quickly and easily and without pain they take up their functions, even in the face of tremendous trauma, if they are given a chance early. Do not let them stiffen. If you do, you will have impaired function for a long time.

By the end of the first week, or before, in nearly all of these cases, the swelling will be of such a nature that a cast is practicable. It should extend in the simple cases only a short distance up the leg. In the more serious, it should reach nearly to the knee.

If the internal malleolus is unbroken, the assistant holds the foot by the toes in strong inversion and hyper-dorsiflexion with a flexed knee, while the surgeon molds the cast. Get the foot well above a right angle and use a light cast.

The cast is put on over stockinette, and the stockinette is not pulled over the foot. It is rolled over, thus preventing any undue pressure on the broken malleolii. A few small strips of metal are incorporated under the heel to prevent subsequent breaking. The cast is cut down the front, when sufficiently hard, a strip one inch in width being removed along the whole length and widened from the ankle forward to from 1½ to 2 inches so as to permit of easy removal. An easy method of splitting the cast is provided by placing two Gigle saws, 1½ inches apart, under the plaster. If these are moved a little before the plaster hardens, they may be used later to split the cast. Many of these cases have a molded leather ankle splint, because of its lightness, by the end of the first week.

After the tenth to the twelfth day, all danger of damage to these injured ankles has passed, if we use care, and all of them are in plaster or molded leather, the patient going about on crutches. After the first few days in simple cases the foot and ankle are soaked in very hot water once a day and carried through their exercises. I use the same treatment in these cases as I have advocated in Colles fractures for many years, but with one difference. I have repeatedly made the statement that an ordinary Colles fracture with anything for retention except a wrist strap after the tenth to fourteenth day was maltreated. I do not mean by that that a patient who has suffered a Colles fracture can throw a base ball on the fourteenth day, or the twenty-first, but I do say that there being no weight-bearing at the wrist, we may dispense with all restrictive apparatus, except the small leather wrist strap, very early. The same would apply to a Pott's fracture except for three factors: the weight-bearing; the weight of the foot itself anterior to the astragalus, and the pull of the gastrocnemius and soleus muscles. These then, must be considered. After the twelfth day, there is little danger of redislocation or damage to the broken parts provided no weight is thrown upon the foot. We cannot permit weight-bearing in any of these injuries at the ankle joint due to leverage until there is no possibility that weight-bearing will cause deformity by bending out the bones on the hinge of soft callus, and we must not permit this until such time as this soft callus has been replaced by bony tissue

Fig. 8. Fracture of internal malleolus from inversion. This fracture is also the result of eversion, sometimes.

strong enough to resist the pressure which it will be called upon to bear.

This is an individual proposition and probably differs greatly in every person, so we must not take chances. One bad result, one foot that turns out progressively after weight-bearing will more than counterbalance good results in a dozen cases. It is probable, and in fact I am convinced, that many of these cases would receive no injury from weight-bearing much earlier than I now permit, but where the individual coefficient of repair is an unknown quantity, we must not take chances, and there is no

Fig. 9. Fracture of both bones from inversion at joint level. Not usually as serious as shown here. It is obvious that a recovery here is possible only by operation and even then is doubtful. Early motion here is out of the question.

necessity for so doing. With motion each day, by the twenty-first day all these cases will be able to have practically normal motion at the ankle, the simple ones much sooner. The ankle will swell and in some of them, cyanosis will be pronounced, but they will all have the normal range with perhaps some slight restriction. So long as we preserve this normal motion against the day when we can with absolute safety permit weight-bearing, we shall have done all that it is needed to do, since in this case, the patient will be able to walk with ease when the time comes, instead of having the recovery of lost motion still before him.

In the simple case of a break of the external malleolus below the joint level, there is no tendency to eversion of the foot. Such a case needs practically no restriction, except care, and may bear some weight with care at almost any time, certainly by the twelfth or fourteenth day. A case of simple break of the fibula above the joint by direct violence, and not a leverage fracture, is held together by soft callus by the 12th day. There is beginning actual bony growth across the break by the 21st day. There is little strain in weight-bearing in such a case, and it does not require a great amount of restriction. By the 20th day such an injury may safely begin to bear some weight, but care must be observed.

In a leverage fracture of the ankle joint, attended by ligamentous tear, and by the potentiality at least of dislocation at the astragaloid joint, by either inversion or eversion, with fracture high up or low down of the fibula, by the 15th day, the foot should be out of the cast for an hour or two each day. It should be soaked in hot water, and active motion in flexion and extension should by this time reach a fairly normal range. No lateral motions should be permitted.

By the 18th day, only a light molded leather ankle strap should be used by day, the cast being used only at night, but the patient should be permitted to sit with the foot resting lightly on the floor without weight; and in the simple cases, with a shoe raised 1-4 to 1-3 inch on the inner side, slight weight-bearing may be begun by the 21st to 30th day, but no great amount of weight should be borne for at least five weeks. We must remember that with this treatment when the patient begins to bear weight, the surgeon has finished the case, and we can therefore afford to go slow. There are no long months of struggle before him for the completion of the motion.

In the serious cases, it is better to wait 6 weeks before weight-bearing. It is safer to do so, and there is little to be gained by hurrying, since the motion has not been lost. In the serious cases with great injury and dislocation, where the man is very heavy, a steel support attached to a padded ring on the leg and inserted into the heel of the shoe may be used for several weeks after walking is permitted, but in the vast majority of cases, this will not be found necessary. The inverted foot and the ankle strap will be sufficient. A leather or a metal foot plate is sometimes added.

The inferior calcaneo-scaphoid ligament, the spring ligament which is one of the important ligaments of the internal longitudinal arch, is rarely injured, but all muscles and ligaments are weak from disuse after a fracture of this kind. It is therefore important to wear a foot plate, but it is of far greater importance to put the injured foot through a period of regular exercises, before weight-bearing is permitted. This is the treatment that should be used in every case of fracture of the ankle, and if used will shorten the time of disability by months. It is unfortunate that in the unintelligent class of people, care will have to be used and the casts left on for a longer period, because they cannot be trusted, and damage suits are

at present far too common to be disregarded. But even in this case, where the casts, for reason of prudence, must be left for a much longer time than necessary, it is incumbent upon the surgeon to see that the mobility of the foot is preserved from the first.

In the eversion type, I always use a shoe of which the inner side of the heel and sole is a straight line, as all shoes should be long enough to sweep wide of the toes.

The inner side of the heel and sole are raised 1-4 to 1-3 inch in order to slightly invert the foot. An inverted foot is always a strong foot, and an everted one is always a weak one.

Fig. 10. Fracture of both bones from inversion, the fracture of the fibula high up. The large piece integral with internal malleolus shows. Internal dislocation is reduced, but there is still backward dislocation. Reduced, this fracture will respond almost as quickly as one apparently much less serious.

CONCLUSIONS.

These leverage fractures of the ankle under compression are all of the same etiology, and vary simply from distribution of force and intensity of stress. This applies to most of the so-called simple fractures of the lower end of the fibula since the salient features of this fracture are present: i. e., ligamentous and tendon injury and a destroyed mortise permitting dislocation. Simple fractures of the fibula at any level—the result of direct violence without ligamentous rupture—does not belong to this type, but there are no compression leverage fractures of this kind involving the ankle joint.

Fractures of the inversion type are not usually attended with so great a destruction of ligaments, but there is an equal or more serious involvement of tendon sheaths, and a greater posterior dislocation is common, in my experience.

The majority of these ankle fractures are not tremendously serious injuries and do not deserve the bad repute which is theirs at present. The bad results have been the consequence of immobilization and misdirection of effort on the part of the surgeon.

Motion, active and passive, from the very beginning, is the solution of the problem. Do not permit the ankle joint to stiffen in the first place. This is easy to prevent. Once it has occurred it is overcome only at the expense of tremendous effort and months of time.

It is easy to reduce an ankle fracture, put it in a cast and look at it once a week, but this is fatal to the patient's function. If time is too precious for one to devote 20 minutes a day to an ankle fracture, he had better turn such cases over to some other surgeon. No masseur is competent to do this work unless he is a surgeon and also competent to remedy any bad result. In the hands of a man who understands the pathology of the lesion, there is no danger.

Fig. 11. Impact splits—posterior.

From the standpoint of both economics and compensation insurance, this is a tremendously important subject. The time lost now, as a result of this injury is enormous. It often extends over periods of months or even a year or more in individual cases, applies unfortunately to the mild type as well as to the severe, and is usually avoidable. A fracture of this type without complications, should be returned to light employment in from 5 to 7 weeks, with a practically normal foot, except for some swelling which in certain cases will persist for a long time.

249 ANKLE INJURIES—ALL KINDS JUST AS THEY CAME.

I		
Fibula alone	138 cases	55.4 %
Broken high	12 cases	4.8 %
Half way	7 cases	2.80%
Clearly at joint or near it	105 cases	42.2 %
Periosteal tears from inversion	14 cases	5.6 %
Ankle dislocated at joint	29 cases	11.6 %
(of whole or 21.01% of number with fibula broken)		
II		
Fibula and internal malleolus	52 cases	20.9 %
Fibula broken:—		
High	16 cases	6.4 %
Half way	1 case	.4 %
At joint or near it	34 cases	13.6 %
Periosteal tear	1 case	.4 %
Internal malleolus broken:—		
At joint level	45 cases	18. %
Low	7 cases	2.81%
Dislocation of ankle	34 cases	13.6 %
(whole series or 65.4% of this class)		
Internal malleolus displaced anteriorly	23 cases	9.2 %
III		
Internal malleolus alone	35 cases	14. %
At the joint level	26 cases	10.4 %
Below half	7 cases	2.81%
Periosteal tear	2 cases	.8 %
Dislocation of foot	12 cases	4.8 %
(of whole or 34.3% of this type)		
Internal malleolus displaced forward indicating eversion	13 cases	5.2 %
IV		
Fractured fibula and separated tibial epiphysis	5 cases	2. %
Dislocated foot	4 cases	
V		
Fractured scaphoid alone	2 cases	.8 %
As complication	2 cases	
VI		
Fractured astragalus alone	5 cases	2. %
As complication	2 cases	
VII		
Fractured os calcis	5 cases	2. %
VIII		
Dislocated foot without fracture	3 cases	1.2 %
Forward	2 cases	.8 %
Outward with lig. rupture	1 case	.4 %
IX		
Impact splits of tibia alone	4 cases	1.6 %
As complication	28 cases	11.2 %
X		
Total dislocation of the ankle, all causes	87 cases	34.9 %
XI		
Clearly inversion fractures	34 cases	13.6 %
Periosteal tears of fibula	14 cases	5.6 %
Periosteal tear of fibula and broken internal malleolus	1 case	.4 %
Broken internal malleolus alone	8 cases	3.2 %
Broken astragalus from impact in inversion	2 cases	8. %
Broken fibula and internal malleolus	9 cases	3.6 %
Fibula high	3 cases	
Fibula at joint	6 cases	
Ruptured inferior tibio-fibular ligaments clearly as evidenced by wide separation of the bones in the *x*-ray plate	30 cases	12.05%

Many others undoubtedly were ruptured, but when the *x*-ray evidence was not conclusive they were excluded.

Reflex spasm is a definite indication after a fracture that motion causes pain. This demand for rest on the part of Nature ought to be respected unless we have clearly in mind some good purpose to be accomplished by disregarding it.—JAMES S. STONE in *Southern Medical Journal.*

TREATMENT OF POTT'S FRACTURE

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The involvement of bone in a Pott's fracture is slight when compared with that occurring in the other common types of fractures of the long bones. Rarely is there a line of fractures involving the entire transverse axis of the tibia, the important weight-bearing bone of the leg, while the fracture of the fibula, although it may be across the entire shaft, does not as a rule involve directly the ankle joint, nor does it occur at a point where any important muscles are attached. And yet the long convalescence and the poor functional end-results in this type of fracture are only too common. There must be some factors other than the fracture of the bone about the ankle joint to account for the marked disability that results so frequently. The mere reduction of the fracture with good position and good union in the fibula and the tibia is not enough to restore normal function in the ankle joint, and normal weight-bearing in the foot. One sees only too frequently a foot in which the line of fracture is well healed and without displacement of the fragments as shown roentgenographically, but with a considerable disability on account of pain and stiffness in and about the ankle joint.

It is the purpose of this paper to take up those other factors that are so important in the proper treatment of a Pott's fracture. A thorough study must be made of the anatomy and physiology of the foot, as well as the pathology of the lesion, and all phases of the subject must be correlated before the subject can be properly handled.

The function of the foot is two-fold: weight-bearing with stability, and propulsion of the body.

In weight-bearing there are two positions or attitudes, one of rest and one of activity. In the position of rest in weight-bearing, such as standing in one position the feet are usually turned outward, the astragalus slides forward, downward and inward and the weight is transmitted largely off the inner side of the foot, and thus through the internal ligaments of the foot. In the position of activity, the normal foot transmits the weight directly through the tarsal and metatarsal bones. These bones are held in a position of stability by the many ligaments of the foot and their proper function is most essential. Any injury that lessens the function of the ligaments will lessen in direct proportion the usefulness of the foot. With every movement of the trunk or

the arms or the head, the center of gravity is changed and the weight is shifted from one set of ligaments and bones to another set and thus the strain upon any one ligament or group of ligaments is relieved.

In a Pott's fracture it is the injury to the ligaments rather than the injury to the bone that makes the seriousness of the lesion, and that must be of first consideration in any form of treatment. Perhaps it would have been better had this been called a Pott's sprain or "fracture sprain."

The structure about the ankle joint involved in a Pott's fracture include the articulating surface of the tibia and the fibula to each other and to the foot and the ligaments of the foot as a whole. The ankle joint or the articulation between the bones of the leg and the astragalus, is a hinge joint in which the motion is almost entirely that of flexion and extension. Inversion and eversion may occur in this articulation to a very slight degree, but they are found to take place largely in the subastragaloid joint.

The bones of the leg are joined to the foot by five strong ligaments:—

(1) The articular capsule, which surrounds the entire joint and varies in its strength and thickness at different places.

(2) The anterior talo-fibular ligament;

(3) The posterior talo-fibular ligament;

(4) The calcaneo-fibular ligament. All of these are fairly strong, but not to be compared with

(5) The deltoid ligament which connects the tibia with the calcaneus, astragalus and the scaphoid. This last ligament is of such strength that it usually resists every force and a fracture of the bone to which it is attached takes place rather than the ligament itself tearing.

The malleoli form a mortise which tightly embraces the astragalus in all positions of the foot, so that any slight degree of side to side motion that may exist is due simply to stretching of the talo-fibular syndosmosis, and to the slight bending of the fibula. This mortise is maintained through four ligaments, the anterior, posterior and inferior posterior, all of which have not much strength, and the interosseous ligament, which is very strong and which is continuous with the interosseous membrane.

A Pott's fracture is caused by either forcible eversion or inversion of the foot. This may be by direct force with the foot being held while the body is twisted upon it or vice-versa, or indirect through the weight of the body acting with the foot held in inversion or eversion.

In the typical Pott's fracture one finds a fracture of the fibula above the malleolus, a tearing of the tibia-fibular band and a fracture of the internal malleolus at its tip. In the milder form of injury we may find in the *x*-ray picture only a fracture of the fibula, while in the more severe forms there may occur besides the fracture of the fibula and internal malleolus, a backward dislocation of the foot at the ankle joint, a fracture of the posterior articulating surface of the tibia and a lateral dislocation of the foot at the ankle joint, which may cause a compound wound. The type and location of the fractures will vary somewhat with the direction of the acting force. If inversion of the foot is the main movement through which the force acts, the internal malleolus is practically always broken squarely at its base and the fracture of the fibula occurs close above the malleolus. If eversion is the direction of the force the fracture of the internal malleolus will be oblique and at the anterior margin of the bone, while the fibular fracture is usually higher and of a spiral type. The fracture of the fibula may be as high as the neck of the bone and thus missed in the ordinary plate made for this type of lesion.

Regardless of the direction of the acting force or the extent of the fracture of the bone there is always a severe and serious lesion of the ligaments. In fact the injury of ligaments must take place before any fracture can occur. Unfortunately the roentgenogram does not show this feature of a Pott's fracture, but emphasizes only the less important lesion of the bone.

If one could observe the different steps as they occur in a Pott's fracture in which the foot is held in eversion, their sequence would be as follows: With the foot fixed and in a valgus position the weight of the body would be transmitted to the inner side of the ankle joint. As this force continues in action the foot would be crowded against the external malleolus, the ankle joint mortise being widened through the tearing of the tibio-fibular band and of the deltoid or internal lateral ligament. The latter, however, being exceptionally strong would not tear in itself but at its attachment to the tip of the internal malleolus. More often the tip of the malleolus is fractured and carried downward and outward (towards the middle of the foot) with the ligament. As the external malleolus is pushed farther outward there occurs a bending of the shaft of the fibula towards the middle of the leg. The bending takes place largely in the narrow part of the bone just above the malleolus and it is here that the fracture of the

fibula is most frequently found. With this widening of the mortise there must necessarily occur some tearing of the other ligaments about the ankle joint. The weight of the body is not only transmitted to the medial side of the foot but also forward and if this movement is carried far enough, a forward displacement of the leg upon the foot at the articulation between the astragalus and the tibia will occur. Frequently with this forward displacement of the leg there will occur a shearing off of the posterior articulating surface of the tibia. If the medial displacement of the foot is extreme there may be a dislocation inward of the leg and the lower end of the tibia will be pushed through the skin, thus compounding the fracture.

The above picture will vary only in a few details when the foot is held in inversion or when the leg is fixed and the force acts through the foot. However, the important features, the injury to the ligaments with a widening of the mortise of the ankle joint and the fracture of the tibia and fibula remains the same.

The symptoms and signs of a Pott's fracture are similar to those found in any other fracture. Pain, swelling, tenderness, loss of function, deformity and later ecchymosis are all observed. Every injury above the ankle joint with any or all of these symptoms should be considered as a possible Pott's fracture. The most common mistake is to make a diagnosis of a simple sprain. In all doubtful cases an *x*-ray examination should be made. If there is a backward displacement of the foot as shown by the angle formed by the tendo-Achilles, a fracture is almost positive. Too much emphasis can not be given to the presence of an ecchymosis, especially beneath the internal or external malleolus. This rarely, if ever, occurs in a simple sprain. It may be caused, however, by any injury that will lacerate or bruise the soft tissues, such as a direct blow. Careful examination of the fibular for point tenderness is most valuable and should be made over the entire length of the bone. I have three cases in which the fracture of the fibula was found by the *x*-ray to have occurred at the neck of the bone, while the other clinical features were in or about the ankle joint. The swelling may occur rapidly and obscure the true deformity of eversion, equinus and backward displacement.

The treatment of the fracture may be either immediate or late. The immediate treatment presents only the problems of reduction, while the late stage has the added features of shortened ligaments and tendons and firm bony union or callus. If possible the reduction of the fracture should be attempted immediately after the accident. Nothing is to be gained by waiting until the swelling has appeared or subsided. Complete relaxation of the muscles is absolutely essential. In a few cases this can be obtained without the use of an anesthetic but in the majority of cases a deep etherization will be required.

The manipulations for reduction of the most common type, that of eversion, consists of three phases. The first has to deal with any dislocation that may be present. With one hand over the lower end of the tibia giving a backward thrust, the other hand is placed beneath the calcaneus and pulls forward. A great deal of force may be used in this manipulation without fear of carrying the foot into a forward dislocation. The next manipulation is to narrow the widened mortise. This may be accomplished by pressing together the malleoli. The third manipulation is a double one and is perhaps the most important step. It attempts to correct the eversion and plantar flexion, and consists in bringing the foot into extreme inversion and extreme dorsal flexion. This step will carry the tip of the internal malleolus upward and medially (towards the inner side of the tibia) and will also to a large extent reduce the fracture of the fibula by bringing it into a straight line. In this manipulation all the attention to the fracture feature of the lesion that is necessary is done.

After the fracture has been reduced a proper splinting is necessary. For this feature of the treatment it is absolutely necessary that the splint hold the foot forward, inverted and dorsally flexed. Any point that does not fulfill these three requirements is not a good splint. Numerous splints have been devised for the control of this fracture, the most popular ones being the ordinary circular plaster of Paris cast, the long wooden splint of Duputyren, the wire splint of Cabot and the plaster of Paris splints of Stimson. The relative merits of these will not be discussed. I have used most successfully the splint devised by Stimson. Not only is its construction and application easy, but the foot is placed and held in the proper position without any pressure, and any swelling that may follow does not necessitate the removal of the splint. This splint consists of two parts, a posterior shell and a lateral shell. After reduction has been made under an anesthetic the foot is well padded under the heel and over the dorsum. A three-inch muslin bandage is then thrown around and under the foot and the assistant by pulling on the two ends of this bandage

maintains the foot in the position of inversion and dorsal flexion. A plaster of Paris slab, the length being from the toes to the middle of the thigh and about twelve or fourteen plies thick is made and molded to the foot and leg by a gauze bandage. Another slab of the same length and thickness is made and molded over the dorsum and around under the foot and up the inner side of the leg, the inner side of the leg being used in order to prevent any pressure over the common peroneal nerve.

At the end of a week the splint may be cut below the knee so that the patient may sit in a chair. At the end of the second week the splints are removed daily and the foot is massaged and soaked in hot water and active exercise is started. If care has been used to separate the two splints by the gauze bandage, the removal of the splint is very easy. The lateral splint may be left off at this time and only the posterior splint used at night. At the end of the third week a shoe with a quarter of an inch lift on the inner side of the sole and heel can be put on and the patient begins to walk with crutches. Weight-bearing can be graduated from this time on but by the middle of the fourth week there should be considerable weight borne on the foot. Active exercise is very important and especially to restore the motion of dorsal flexion. This can be obtained by using a sewing machine or a foot lathe. It is most important that the corrective shoe be worn at all times for at least six months. If the patient develops soreness on the outer side of the foot, the elevation can be removed from the sole and a Thomas heel with a quarter of an inch elevation on the inner side be substituted.

The prognosis can not be determined by the *x*-ray findings. I have records of a compound Pott's fracture with a fracture of the fibula and tibia and a backward and lateral dislocation of the foot in which case the patient resumed his work at the end of nine weeks, and, by contrast, of a case in which the *x*-ray showed only a fracture of the fibula and a very small piece of the internal malleolus torn loose, in which the disability lasted for four months.

In old fractures with unreduced displacements relief can be obtained only through operation. The most popular operation is an osteotomy of the tibia and fibula in order to correct the weight-bearing of the foot by bringing the foot back into line with the leg. However, this does not relieve the disability caused by the backward displacement of the foot which occurs in practically all cases and limits flexion to such a degree that every step is painful. This feature may be overcome by doing the operation suggested by Stimson in which the ankle joint is opened by a medial and lateral incision and the normal position of the foot restored. However, the prognosis should always be guarded in these old fractures as not infrequently there is not any improvement in function.

CLINICAL OBSERVATIONS ON PELVIC FRACTURES

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While for many years pelvic fracture, with or without complicating damage to the genito-urinary apparatus, has been recognized as a serious surgical lesion, the subject has received meager consideration in urologic and surgical text-books and also in current medical literature. Pelvic fracture must either be exceedingly uncommon, or has often remained unrecognized and undiagnosed, since it appears there have been less than two hundred cases reported in the literature of the world. The largest collection is that of Quain (1915) which includes a total of 127 cases. Since then probably not more than forty additional examples have been recorded.

It is estimated that in about sixty per cent of instances pelvic fracture is accompanied by bladder or urethral injuries, usually both. There is practical agreement that the most serious aspect of this type of fracture consists in concomitant damage to the urethra, the bladder, the rectum, the pelvic bloodvessels and nerves. The location and extent of the osseous lesion may bear no relationship whatsoever to injury inflicted upon adjacent structures. Bladder rupture may be either intra- or extraperitoneal, and may be caused by inordinate pressure of puncture from bony spiculæ. Urethral damage is usually in the most fixed portion of the canal, i. e., the membranous region. The anterior rectal wall seldom escapes injury in extensive pelvic fractures, especially those involving the sacrum. The bloodvessels and nerves occasionally escape regardless of the location of the osseous lesion.

CASE REPORTS

CASE I. C. D., negro, 35, was brought to Louisville on a stretcher eight hours after a railroad accident. Examination disclosed the following injuries: (a) complete transverse rupture of the membranous urethra, (b) rupture of the bladder, (c) laceration of the anterior wall of the rectum, and (d) bilateral fracture of the pelvis.

The patient showed moderate shock, but was conscious and complained of pain in the back, hips, and lower abdomen; pulse 96, temperature 101°F. He was unable to stand because of severe pain. Roentgenoscopy at the hospital confirmed the clinical diagnosis of bilateral pelvic fracture.

Attempts to introduce a catheter beyond the membranous urethra were futile, and when withdrawn the instrument showed the presence of blood, but no urine was obtained. There had been no micturition since the accident. There was marked ecchymosis about the pudendal and inguinal regions, and considerable urinary extravasation into the perineum, scrotum and surrounding tissues. Notwithstanding the serious nature of the injuries sustained, it was deemed advisable to give the patient the only chance of recovery, i. e., immediate operation.

Median line incision under ether anesthesia. Peritoneal cavity contained large amount of blood-stained fluid, having urinous odor. Bladder walls ecchymotic, cavity partially filled with bloody urine, one inch rupture in right lateral wall extending toward fundus. This opening was quickly sutured with silk and the abdominal incision was closed without drainage.

Perineal section was then performed, and after identifying proximal and distal ends of ruptured urethra, a catheter was introduced into bladder cavity for permanent drainage. Urine drained freely and remained blood-stained for three days, then became clear.

Because of the complicating injuries the pelvic fracture was treated by strapping with adhesive plaster, no mechanical device being employed.

Despite the serious damage inflicted and the rather extensive operative trauma, the patient reacted well from the operation and lived for twenty-one days, then perished from peritonitis of colon bacillus origin.

CASE II. B. W., male, 20, white, farmer. Injured in collision between automobile and railroad train. Pelvic fracture, urethral rupture, fracture of right arm, dislocation of right elbow, cerebral concussion, lacerated scalp, right side. Shock profound when patient was first seen; this continued and death occurred twenty-four hours after accident. No urine voided after injury.

CASE III. L. B., male, 21, white, farmer. Accident similar to the foregoing. Roentgenoscopy: fracture of horizontal pubic ramus with displacement downward blocking obturator foramen; horizontal ramus fragment 2½ inches long; pelvic articulation showed downward displacement of right segment; right sacro-iliac joint widened, slight downward displacement. Intra- and extraperitoneal vesical laceration; extravasation of blood and urine into lower abdomen and pelvis.

Celiotomy: vesical laceration repaired, suprapubic drainage; adhesive plaster dressing applied. Patient reacted from shock and lived about six weeks, then died of peritonitis due to colon bacillus infection.

CASE IV. J. F., male, aged 50, superintendent of salvage corps. Automobile collision, patient projected through wind-shield, fracturing left hip; head of femur driven into pelvis, acetabular splintering. Roentgenoscopy: wedge-shaped piece of bone about two inches long projecting into pelvic cavity. Extension treatment employed. Patient in hospital two months; partial disability two months after dismissal; then resumed business, only infirmity slight limp.

CASE V. J. K., male, 31, brakeman, fell from car door, striking left hip across rail. Acetabular fracture, splintering of bone and projection into pelvis. Treated by extension method. In hospital two and one-half months; resumed work at end of five months.

CASE VI. J. McD., male, 51, foreman. Machine shop accident. Fracture of ascending and horizontal pubic rami. Canvas dressing tightly applied laced in front. Voided bloody urine for seven days, but finally made complete recovery. Time in hospital about one month; resumed work at end of three months.

Etiology: Pelvic fracture occurs rather unequally between the sexes, males being more susceptible than females for occupational reasons. It is usually produced by traumatic (crushing) agencies externally applied, e. g., the wheels of heavy automobiles and other vehicles passing over the body; the impact of an approaching object while the individual is placed against something immovable; railroad accidents, street car and automobile collisions, etc. The lesion may also be produced by falls in which inordinate force is transmitted from the feet, thus driving the end of the femur through the acetabulum; by alighting upon the sacrum, the ischial tuberosities, or wings of the ilium. Fracture and splintering of the pelvic bones may result from gunshot wounds and many other common and uncommon traumatic agencies.

Separation of the pubic symphysis is a rather frequent lesion, although literally not a true fracture, and may be produced by difficult parturition in primiparæ, by muscular exertion incident to certain occupations, and otherwise. Separation of the anterior or posterior pelvic ring usually occurs from heavy weights passing over the body. Unilateral or bilateral separation of the sacro-iliac synchondrosis is uncommon and is usually associated with extensive damage to other portions of the pelvis. The most frequent sites of pubic bone fracture are through the horizontal ramus near the pectineal line, and through the descending ramus.

Sacral fracture is caused by forcible bending inward of the apex. When such an accident occurs vesical paralysis may ensue. (Agnew). Coccygeal fracture (or dislocation) may result from inordinate external violence, or rarely (in women) from difficult childbirth. Fracture of the ischium or ilium without injury to other portions of the pelvis has been rarely observed.

Symptomatology and Diagnosis: The clinical symptoms in uncomplicated pelvic fracture are not always of sufficient gravity to suggest osseous damage, and early diagnosis is often difficult of accomplishment without aid of roentgen ray; and let it be

said this agent should be employed in every instance of suspected fracture to confirm or nullify the clinical findings.

In complicated fracture the individual complains of pain in the lumbar region, often in the thighs and lower abdominal area, depending upon the location and extent of the damage. The fact is noteworthy that even in serious lesions no osseous deformity may be evident. Shock is an important symptom and is always present in greater or lesser degree. Local signs are noted when the patient attempts to assume the upright posture, and if the injury be unilateral there is outward rotation of the affected limb. Elevation of temperature is a constant symptom, unless shock is inordinately profound, and the pulse is generally accelerated, probably due to trauma and hemorrhage. Abdominal signs are present when visceral damage has occurred. Extensive contusion of soft tissues may distract attention and entail diagnostic confusion and delay. Differentiation from hip fracture or dislocation must be made by the *x*-ray.

In practically every pelvic fracture, whether complicated or otherwise, within twenty-four hours there will appear more or less ecchymosis about the inguinal regions, also the perineum and scrotum in males, and the perineum and labia majora in females. However, the observation is important that where fracture is confined to either iliac crest this sign may be absent. Crepitation may not be evident excepting where the head of the femur has been driven through the acetabulum, in which event so-called "soft" crepitus can usually be elicited. For obvious reasons, in the presence of shock, great caution should be exercised in seeking to establish this phenomenon.

Definite areas of fixed pain should always be sought during physical examination, provided the patient be conscious and thus able to intelligently cooperate with the attendant. Flexion of the limbs may produce no increase in fixed pain, whereas pulling or pushing in the long axis almost invariably causes complaint from the patient.

Increase of pain on pressure over the ilium, the greater trochanters and the pubic rami, is a most dependable sign in the clinical diagnosis of pelvic fracture regardless of its situation or type. The location of the pain often suggests the site and also probable extent of the osseous damage. Pelvic or other measurements afford no information of value excepting in acetabular perforations.

Where serious vesical and urethral damage has been inflicted, the immediate history will be definitely indicative. Local pain is more severe, micturition is impossible, the catheter cannot be introduced into the bladder cavity, and there is more or less urinary extravasation into adjacent soft tissues. Under such circumstances, unless adequate treatment is promptly instituted, infection, peritonitis, and fatality may be confidently anticipated as the logical ultimate outcome.

Prognosis: The prognosis of pelvic fracture must always remain an uncertain quantity as it depends upon quite a variety of factors, e. g., the character and extent of the osseous, integumental and visceral injury, the physical resistance of the individual, the degree of primary shock, the operative and post-operative care. The clinical dangers are markedly enhanced by concomitant bladder or urethral damage, and also by the involvement of iliac bloodvessels and pelvic nerves. At all events, the surgeon should be extremely cautious in his prognosis, especially in complicated cases, bearing in mind the possibility of post-operative infection and fatal peritonitis. In some instances the patient is practically moribund when first observed because of trauma, shock and hemorrhage, and in such event surgery is unavailing and dissolution inevitable. Not a few case records have detailed this sequence of events. The most that one can say is that the prognosis must remain uncertain under any circumstances.

Treatment: The treatment of pelvic fracture will probably never be accurately standardized, since modifications are necessary to meet individual indications. The procedure selected will depend largely upon the physical status of the patient when observed the nature and extent of the osseous, integumental and visceral damage.

In separation of the pubic symphysis or sacro-iliac synchrondrosis (technically not fracture), and in uncomplicated lesions involving the ilium and ischium, operative measures are seldom required. Quietude in the recumbent position must be enjoined, adhesive plaster or a tight bandage applied, and suitable pads adjusted to relieve pressure, to prevent displacement, and to insure comfort to the patient during the reparative process.

In coccygeal fracture, if pain be severe and continuous, amputation is probably the most appropriate method of management. In sacral injuries there is usually more or less rectal implication. The introduction of a gauze-covered tube of proper diameter assists in maintaining apposition of fragments, prevents deformity, and facilitates repair of lacerated tissues.

Where the head of the femur is driven through the acetabulum, Buck's extension apparatus is required.

A perineal strap is also useful in forcing the head of the bone outward.

Complicated pelvic fractures require the early invocation of rational surgery to conserve life. In compound fracture detached and devitalized fragments should be removed and gauze introduced to control hemorrhage. Mechanical devices, externally or internally applied, to maintain fragments in apposition, are sometimes advantageous.

In my opinion, the Bradford frame or similar apparatus is of decided value in the management of practically all types of pelvic fracture. By this means the comfort of the patient is enhanced because of freedom from pressure, he may be moved as required without pain, and the work of the nurse is thereby greatly facilitated.

There is much divergence of opinion concerning the most effective dressing for pelvic fracture. Some surgeons prefer plaster of Paris, others employ adhesive strapping exclusively. In my judgment, the best dressing is a canvas binder which can be laced in front or back like a shoe. This type of dressing tightly applied will control the pelvis effectively.

Concomitant vesical and urethral injuries deserve special mention as they are the most serious complications incident to pelvic fracture, and conservation of life is often predicated upon promptness and thoroughness of surgical repair. For obvious reasons extraperitoneal vesical rupture is infinitely less dangerous than the intraperitoneal type. In either event, however, the vesical aperture must be adequately closed by suture to prevent further urinary leakage, although some surgeons have stated that the vesical wound requires no surgical attention after urethral drainage has been established. Urethral rupture is repaired by perineal approach and an indwelling catheter inserted for prolonged drainage. The tissues regenerate around the instrument and reestablishment of the urethral lumen is thus accomplished. Complete tissue restoration and recovery may be anticipated provided the supervention of infection and peritonitis can be prevented. Multiple punctures of the soft structures are sometimes required where extensive urinary infiltration has occurred.

Pelvic fractures are comparable to similar injuries of the cranium in that damage to adjacent structures is of infinitely greater importance than the solution of osseous continuity. In pelvic fracture if no injury were inflicted upon the soft parts the treatment would be markedly simplified. The fact remains, however, that in about sixty per cent of instances the bladder and urethra are implicated in greater or lesser degree, and in some cases there is also laceration of pelvic tissues with injury of bloodvessels and nerves. The most careful observance of aseptic technic is a primary and essential prerequisite in the treatment of fractures in any anatomic situation, especially where visceral or integumental damage has been inflicted, the principal danger to life being from infection. In pelvic fractures the mortality is high, fatality usually resulting from peritonitis. Early deaths are commonly due to the effects of shock, hemorrhage and the accompanying trauma.

Survey of the literature for 1923: Several contributions to the subject of pelvic fracture have appeared during the last year. So far as available, these will be reviewed in abstract form.

Miginiac summarizes 92 cases of pelvic fracture produced by contusion, the list including several unpublished cases from his personal experience. He expatiates on the advantages of exploratory celiotomy and cystostomy in all such instances. No further details in abstract from which these data were obtained.

Hancock records the case of a female, 18, whose automobile collided with a railway train, producing fracture of right pubic bone and right ischium, also vesical rupture 1¼ inches long extending downward and backward obliquely toward right. When observed, six hours after accident, she complained of pain in right hip and back and exhibited moderate shock. No urination since injury; catheterization, four ounces bloody urine withdrawn. Sterile water, 200 c.c., injected into vesical cavity; only 110 c.c., returned; highly colored with blood. Immediate celiotomy: extensive ecchymosis entire upper vesical exterior and surrounding tissues. No discoloration noted until fascia divided, the integument appearing normal. Abdominal cavity irrigated with warm saline solution; vesical rupture closed by "through-and-through" method reinforced by Lembert suture; retention catheter employed. Large tube and cigarette drain in abdominal cavity. Patient placed in partial Fowler position, hypodermatic injections morphine (⅛ grain) and adrenalin (5 minims) every three to four hours to combat shock. The patient recovered.

In his commentaries Hancock tritely observed that "the surgeon in the Virginia Rappe case has been criticised, but he may not have been at fault, as it was stated that the patient was intoxicated and there was no history of trauma. When it was discovered she was not voiding, it was probably too late for an operation to save her life." The fact is quite properly emphasized that it is conservative surgery to explore the cavity whenever there is reason to believe a gross lesion of an abdominal organ exists, "and we should not wait in a case like this (i. e., the one reported) where it was absolutely certain, or one where it is probable, but operate whenever it is suspected."

Generally speaking, says Bejul, pelvic fractures have received meager attention, clinical observations have been insufficient, and studies on cadavers have not clearly explained the mechanism of their occurrence. Statistics regarding the incidence of pelvic fractures vary greatly. Gurlt claimed they constitute 0.31 % of all fractures, other authors estimate the incidence as high as 2.93%, while according to material of the Moscow Hospitals it is only 0.03% (Duchonin). Pelvic fracture may not only be caused by direct external trauma, but muscular contraction is also important. Bejul collected 97 examples from the literature and reports two cases personally observed. (1) Female, 50, automobile collision; vertical fracture of ilium and other injuries. Death occurred one and one-half hours after accident. (2) Female, 36, street car accident. Diagnosis, symmetrical fracture anterior pelvic ring with upward dislocation right ilium. Roentgenoscopy revealed fracture left horizontal pubic ramus and ascending ramus of ischium, with splintering and dislocation right ilium. Treatment, extension, twelve pound weight right leg, five pound weight on left. Pelvic measurement fourteen days later showed decrease in dislocation.

Patient recovered and was able to walk after three months. Extension is considered efficient method of treating pelvic fractures. Periodical measuring and roentgenoscopy important. Massage and exercise may be begun during early weeks. Bed rest for eight to ten weeks necessary. Prognosis usually unfavorable. In the 97 collected cases the mortality was 33%.

In 7 patients with pelvic fracture observed during one year by Guibal, urinary tract complications were noted in only two, and, strange to say, in these the fracture was insignificant. The other five had extensive fractures, yet there was no involvement of the urinary apparatus. Urinary complications following pelvic fractures may be classified as intra- and extraperitoneal bladder rupture and rupture of the membranous urethra. Intraperitoneal rupture is characterized by an empty bladder on catheterization and "typical signs of peritonitis." It is repaired by medium suprapubic celiotomy and employment of an indwelling catheter. In extraperitoneal rupture small quantity of bloody urine withdrawn by catheterization, similar fluid invades space of Retzius, iliac fossæ, labia majora or scrotum, and dissects beneath skin of abdomen and thigh. Operative approach is through median suprapubic incision, vesical rupture closed and permanent catheter inserted, or, if necessary for adequate drainage, cystostomy without indwelling catheter. In rupture of membranous urethra vesical cavity full, viscus tender, painful, reaching above pubes; patient desires and tries to micturate but cannot; perineum free, scrotal skin dark-hued and infiltrated. Rectal examination reveals marked infiltration in prostatic region where catheter meets obstruction and on withdrawal is covered with blood, but no urine is found. For relief and repair, suprapubic cystostomy sufficient size to admit No. 20 catheter. After symptoms of shock have subsided, transverse perineotomy, catheter introduced through urethra and allowed to remain three to four weeks. Reconstruction of membranous urethra occurs about instrument.

Statistical study presented by Orator is based upon 70 cases of pelvic fracture observed during twenty years in a large foreign clinic. Pelvic fractures are classified, topographically, as: (a) of anterior ring, with and without complications, (b) of acetabulum, (c) of ilium, (d) of posterior ring, and (e) double vertical type of Malgaigne. The following sequelæ were noted: (a) disturbance of standing, walking, motion in general, (b) urinary and rectal distress, (c) nerve and blood vessel changes, (d) genital functionary changes, (e) deformity, and (f) vocational unfitness. Fractures of the posterior ring disposed to nerve disorders; those of anterior ring to urethral and vesical disturbances usually grave in nature. Sixty-one patients were followed after dismissal from hospital. Seventy-five per cent of these were between 15 and 40 years of age. Etiologically there were three groups: (1) occupational, as in train workers, (2) suicidal, after jumping from heights, and (3) casual, as in automobile accidents. Immediately after injury the cases may be grouped as: (a) isolated fractures without discontinuity of weight-bearing portion of pelvis; (b) fractures causing discontinuity of pelvic ring, requiring a long time for healing, and (c) vertical double fracture of Malgaigne, in which occurs marked dislocation of entire pelvis. Of the 61 patients 15 died. There were seven early deaths due to shock and collapse. The cause of late deaths were: pneumonia, heart failure, pyemia, ascending pyelonephritis, and tetanus. The time required in hospital and for further convalescence varied considerably: (1) for anterior ring fractures, 25 days in uncomplicated and 41 days in complicated cases, with two weeks to three months further convalescence, (2) for acetabular fractures, 30 days in hospital, and further two weeks to one year at home, (3) for iliac fractures 14 days, then no further attention, (4) for posterior ring fractures, 145 days, and further four or more months, and (5) for fractures of Malgaigne, 34 to 110 days, with convalescence at home of at least three months. There were 39 healed and 22 unhealed cases. Healing occurred without social (vocational) disability in 80% of the anterior ring and marginal fractures, in 50% of the acetabular fractures, and in only 25% of the posterior ring and Malgaigne fractures.

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FRACTURES OF THE HUMERUS.*

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Fractures of the humerus are of unusual interest on account of the impossibility of completely immobilizing by any form of apparatus. It has been contended that slight motion between fragments is conducive to union, but the fact that delayed union and non-union occur more often in the shaft of the humerus than any other long bone, is sufficient evidence to refute such contention without further consideration.

An analysis of 314 fractures of the humerus compiled from private records, for the past five years, forms the basis of this discussion. Of this number 131 were in the lower extremity, 36 in the head of the humerus and 147 in the shaft. Fractures of the head of the humerus, involving the shoulder joint, and of the lower extremity in proximity to the elbow joint, will not be further mentioned as each location is a clinical entity worthy of special consideration as a separate subject.

Of the 147 fractures of the shaft of the humerus, 73 occurred in the upper third, 36 in the middle third and 38 in the lower third. No fracture can be intelligently considered without due regard to anatomy, especially the relation of the muscles to the point of fracture. In the upper third the powerful pectoral muscles displace the distal fragment forward and inward. In the middle third the deltoid displaces the proximal fragment outward. In the lower third the distal fragment passes forward from the force of the gravity through the weight of the dependent forearm, as there are no muscular insertions in this region. The brachialis anticus and triceps completely cover the bone, their action being neutralized by the flexed position of the elbow. The weak supinator longus and extensor carpi radialis longior have no definite influence. The musculospiral nerve is regarded as an important factor on account of the close relation to the bone, but with the conception of compound fractures from without, such as gunshot wounds, the danger of permanent injury is probably overrated. However, Von Bruns compiled 77 injuries of the musculospiral nerve, but does not state how many were seriously impaired. In 147, under consideration, about 15 gave evidence of injury to the musculospiral nerve, but in only one,

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the result of gunshot wound, was there permanent loss of function. Above the elbow the shaft of the bone is well padded with fat and muscles, allowing ample space for callus expansion without undue pressure on the nerve trunk. In the lower third the brachial artery may rarely be injured by the distal fragment.

The type of fracture may be spiral, oblique, transverse, comminuted. In the upper third the transverse predominates, in the lower third it constitutes about fifty percent, while in the middle third a transverse fracture is extremely rare, though more common in children than in adults. The long spiral fracture occurs more frequently in the middle and upper third, rarely in the lower third. Comminution is more frequent in the middle and lower third, with separation of a loose fragment, or there may be a loose segment of bone which might be described as two separate oblique fractures. These loose particles have been described as due to the action of the deltoid muscle, but as this type occurs as often below the insertion of this muscle, and when in the region of the insertion there is often no displacement, the cause is in all probability tortion force; besides the prototype of this fracture occurs in the lower third of the femur which cannot be credited to muscular action. Atypical relations of fragments occur from unusual forces or extensive tissue destruction in any location.

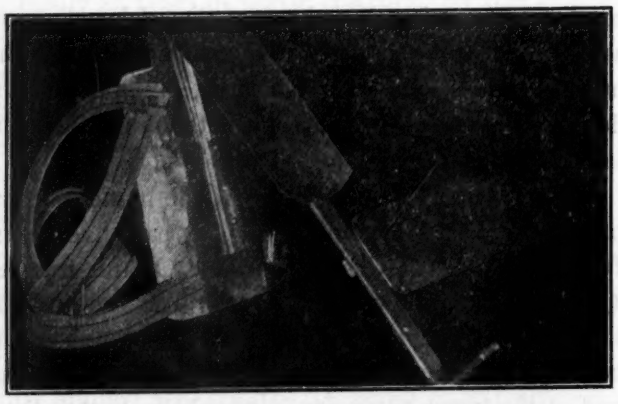

Fig. 1. Simple traction splint, as described in text.

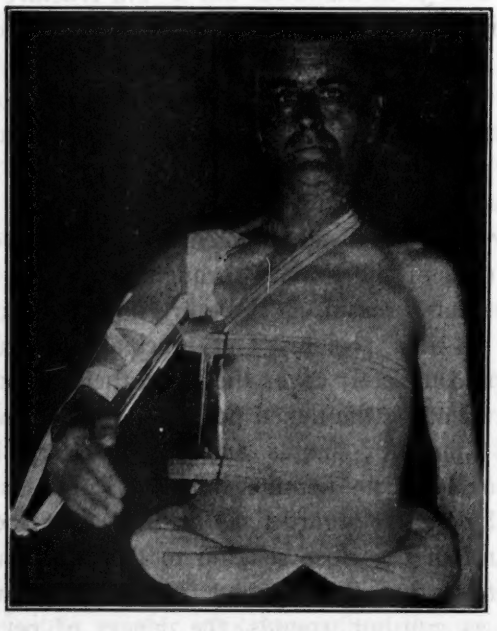

Fig. 2. Front view of traction splint applied for fracture of the middle third.

Fig. 3. Traction splint, side view.

Of the 147 fractures of the shaft of the humerus, 20 were compound, 11 were due to gunshot wounds and 9 to ordinary violence. Of the 11 gunshot wounds, 5 were in the upper third, 5 in the lower third and 1 in the middle third. Of the 9 from violence, 6 were in the lower third, 2 in the upper third and one in the middle third. As is evident, com-

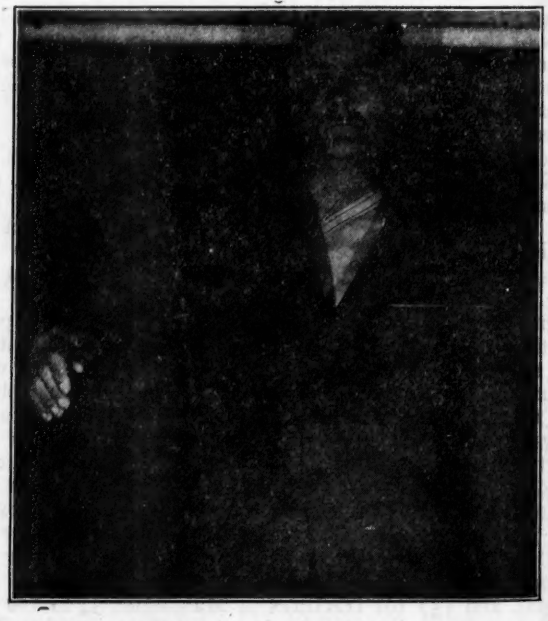

Fig. 4. The same patient with traction bar removed, making a convalescent splint permitting the wearing of clothing.

pound fractures are by far more frequent in the lower third and quite rare in the middle third. From ordinary violence the skin is penetrated when the lower fragment passes forward by gravity of the dependent forearm, which may also sever the brachial artery, as occurred in two instances. In only one of the 20 compound fractures was there a permanent injury to the musculospiral nerve, and in this case from gunshot wound. In one there was gas infection. There was staphylococcus infected in a majority of cases, which subsided with efficient drainage and Carrel-Dakin's treatment.

There were 17 ununited fractures, 4 of which

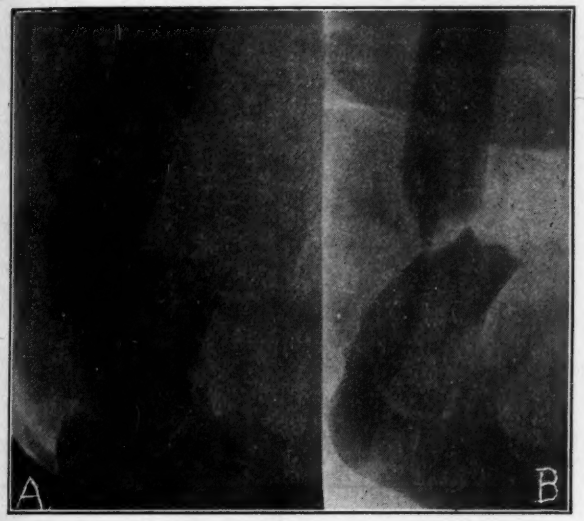

Fig. 5. Transverse fracture of the lower third with anterior displacement of the lower fragment. A—Before reduction. B—Satisfactory reduction and retention in plaster cast.

were compound and 13 simple fractures; 9 were in the upper third, 5 in the middle third and 3 in the lower third. As it is manifestly more difficult to immobilize the upper third, on account of the change in body position, standing, sitting, reclining and the respiratory movements of the thorax, mobility is evidently an important causative agent in non-union. All 17 were first observed after they had reached the state of permanent pseudarthrosis. In fact in a series of approximately 2000 fractures observed by myself and my colleagues, not one non-union occurred except in the neck of the femur in the aged, and then in only 10 percent, which we believe to be largely the result of complete fixation after satisfactory reduction.

The principle in the treatment of fractures of the humerus does not differ from that of other long bones, except that the problem of fixation is more difficult. The methods in general use are inadequate or ineffectual and responsible for the general admission that pesudarthrosis is more common than in any other long bone. There are two methods by which approximation of fragments may be retained, first, by engagement of fragments with end-to-end approximation by the means of external forces and is applicable only to transverse fractures, or in irregular fragments when a dovetailing or interlocking is possible; second, by constant fixed traction, which may be accomplished by forcible traction on a fracture table, with the application of apparatus as a plaster cast to maintain reduction, or by continued traction with apparatus.

In transverse fractures reduction can seldom be accomplished by traction but it can be done without

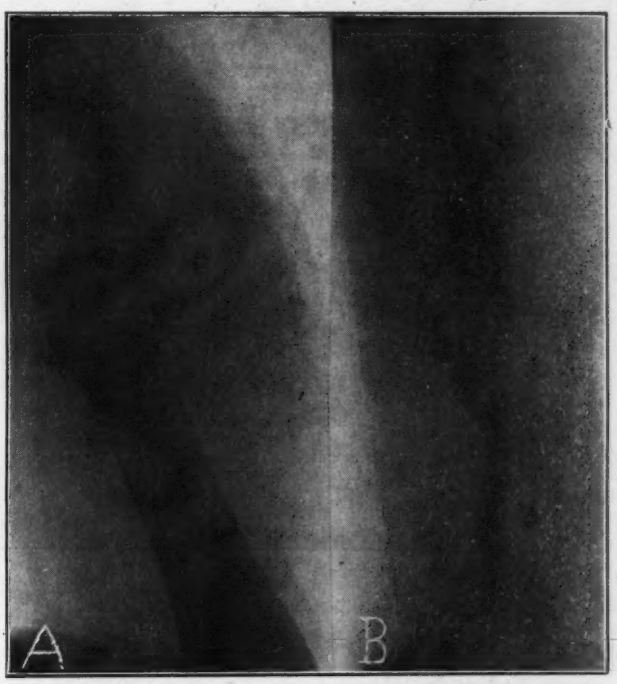

Fig. 6. Typical comminuted fracture of the middle third, with separation of the complete segment. A—Before reduction. B—After reduction with traction splint.

difficulty by angulation until there is end-to-end approximation, with engagement of fragments when the bone is brought into perfect anatomical alignment. It is not always possible to obtain 100% approximation, but 50% is sufficient to restore perfect function, which is all that could be desired. After reduction, retentive apparatus, as will be described below, or a plaster of Paris cast is applied; if the latter it should extend from the palm of the hand including the entire body to the crest of the ilium. The elbow is always flexed from 90° to 120° to relax the muscles that pass from the arm to the forearm.

In oblique or spiral fractures it may be necessary to disentangle fragments from soft parts to secure approximation, after which sufficient traction and rotation is made until there is desired approximation, when retentive cast or apparatus is applied.

If there is a tendency to angulate, or a displacement of loose fragments, special felt pads may be

employed with pressure to maintain anatomical alignment.

Under no circumstances should the elbow be placed in extension, especially in fractures of the lower third, as this position throws the lower fragment forward in dangerous proximity to the brachial artery, which may be occluded with resultant gangrene. If the deltoid is antagonistic the shoulder

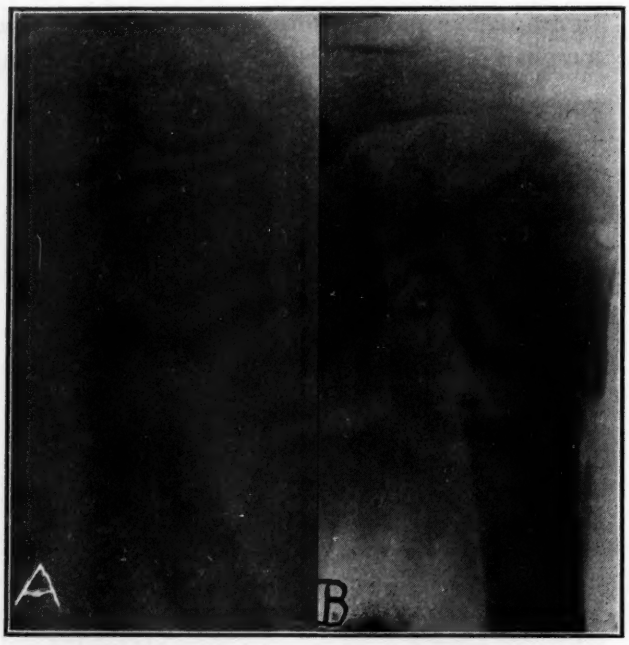

Fig. 7. Transverse fracture of the upper third. A—Before reduction. B—After reduction, with retention in traction splint.

is abducted, if the pectorals, the humerus should be rotated inward.

During the war we saw reports of marvelous reductions of fractures by the Balkan frame, which apparently promised to revolutionize previous methods, but these fractures were free from muscular action by destruction of the soft parts, which differ materially from those encountered in civilian practice.

The object of our efforts has been to secure approximation and to enjoy apparatus that can be adjusted within a few days, so that the patient might return to his home for convalescence without the necessity of constant attention. It might be possible, by complicated apparatus and hospitalization until union is firm, to secure better anatomical relations but surely no better functional results. Any procedure to be universally employed must be within financial reach of the average individual.

In a majority of cases we have employed a simple traction splint, which is a modification and addition to the splint advocated by N. S. Henderson. The apparatus consists of a large metal plate to conform to the lateral aspect of the thorax, which is united to the arm piece in the axilla, the width of which conforms to the size of the arm and passes down the inner aspect to the elbow, and thence down the palmar aspect of the forearm and hand, with the elbow at right angles and the forearm in mid-position. An inner metal bar is attached to the inner surface of the arm portion to three or four inches below the

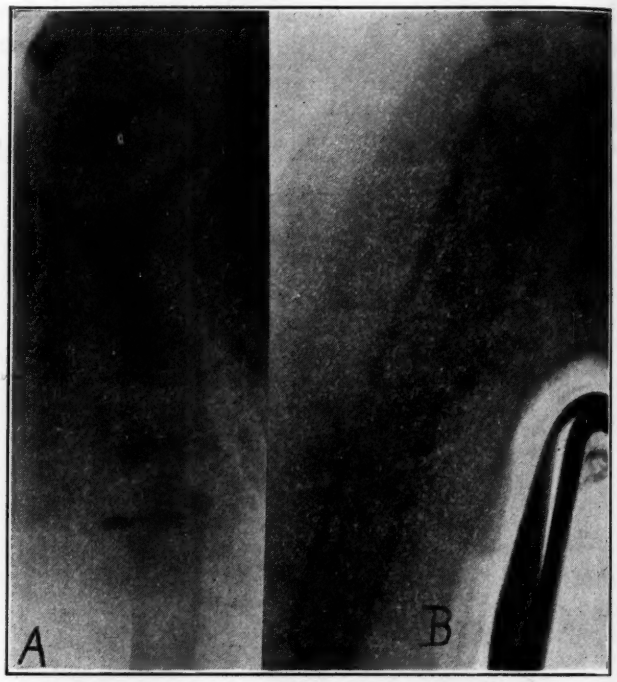

Fig. 8. A—Ineffectual bone graft hardly detectable by *x*-rays, anchored by steel drills. B—Same case after autogenous massive bone graft and nails.

elbow and is then bent outward to right angles, for the attachment of the traction straps. Adhesive straps are applied to the arm from the point of fracture to well below the elbow, after which the splint is adjusted and held in position by adhesive plaster and webbing straps. After sufficient traction the adhesive straps are attached to the steel bar. Traction can be daily increased if necessary to secure reduction. When union is sufficient to restrain the fragments the steel bar may be removed and the remainder of the splint worn, which permits the wearing of a dress or coat. This apparatus is well adapted to factures of the upper and middle third, and as a convalescent measure in the lower third where the distal fragment is often too short for sufficient traction.

Open reduction is seldom necessary in single fractures. In only six transverse fractures in the upper third has an incision been made, when it was thought approximation could not be secured and maintained. The fragments were reduced and held in situ by chromic catgut or silver wire, after which a cast or traction splint was applied. With our present knowledge it is doubtful that it would have been necessary

to operate in even this small number; in fact, it is very rare that reduction cannot be secured by external means, if earnest and intelligent efforts are applied.

In all fractures apparatus should be removed for inspection before consolidation is complete, so that deformity can be easily corrected. As soon as union is well advanced the splint should be removed for daily gentle massage, active and passive motion

Fig. 9. Autogenous graft for ununited fracture of middle third. Complete fixation and consolidation.

of joints, but with care to avoid strain at the point of fracture. The elbow can be released, allowing active and passive motion by the patient at certain intervals during the day.

When a fracture reaches the stage of permanent pseudarthrosis there should be no temporizing. Effective operative measures alone are indicated. No foreign substance, such as steel or beef bone, should be employed, for such materials repel bone production, as is evident in the roentgenograms, which show greater callus on the opposite side of the bone, with often no callus about the internal fixation apparatus. The autogenous bone graft alone is worthy of consideration as a means of internal fixation, for it not only is well tolerated but promotes osteogenesis, which is always deficient.

Complete fixation of an ununited fracture by the autogenous graft is often attended with difficulty and requires painstaking care; in consequence, there are many failures from apparent inability to apply efficient mechanical principles, as evidenced in the roentgenograms of a number that have been observed. The grafts are often too short, at time a mere splinter or peg. A large graft may be loosely attached and not conforming to the contour of the bone, or the graft may be placed under stress. The vitality of all grafted tissue is below normal and should not be placed under any condition that will impair its vitality. No one would think of placing a skin or fascial graft under stress, but this seems to be frequently demanded of bone, which always dissolutes at the point of strain, as has been observed in fixation operations on the spine, when a

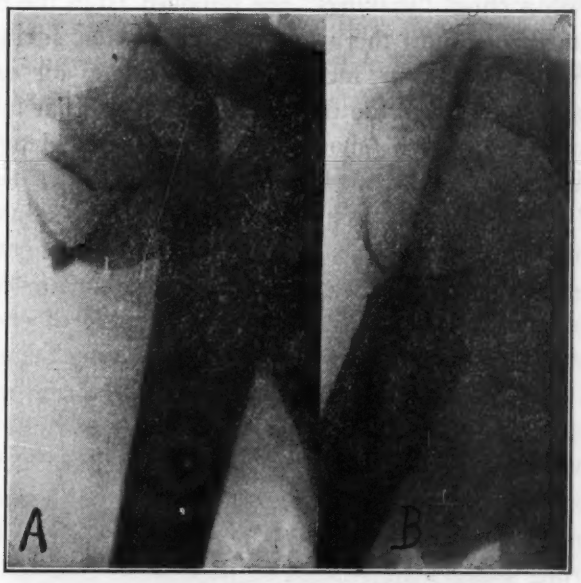

Fig. 10. A—Fracture of the upper third with dislocation of the head and non-union. B—same case after massive graft—and solid union.

straight bone graft is made to conform to a convex kyphotic spinal column.

In our present state of development a bone graft operation is without standardization and most indefinite. When a hysterectomy or an appendicectomy has been performed it is well to know what has been accomplished, but a bone graft may be a mere characture of an effective procedure.

There are two prime factors to which we must closely adhere in ununited fractures; first, the promotion of osteogenesis and second, complete internal fixation. The former is met by several well known procedures, but it has been impossible, by any of the methods in general use, to restore a solid firm continuity without at least feeble movement at the point of fracture, which it is thought might cause failure in a small percentage. With this in view the following procedure was evolved (a preliminary report of which was published in the AMERICAN JOURNAL OF SURGERY, January, 1923):

Ample incision is made through the skin in order to expose each fragment, when possible, for four inches. Routine dissection is made to the seat of fracture; all intervening scar and fibrous tissue is

removed; the fragments are pared with chisel or motor saw and each medulla is reamed out until normal marrow tissue is reached. The fragments are rotated until normal relation has been restored. An incision is made through the periosteum of each fragment, for several inches, depending on length and anatomical location. The periosteum is stripped from one-half to three-fourths of an inch from the circumference leaving attached, as much as possible, the soft parts from which circulation is derived. With a chisel "shavings" are removed from the circumference until there is a continuous, flat surface, for three or four inches, when possible, on each fragment. From the tibia is taken a broad flat massive graft, which should be of sufficient length, breadth and dimensions, to secure firm fixation. With a motor saw the graft is split longitudinally through the edge or small diameter into two parts, a strong outer plate consisting of dense bone or cortex, and an inner, the endosteum. A strip of endosteum is placed within the medulla, bridging the seat of fracture as reduction is made, thus restoring normal marrow tissue rich in osteoblasts. From the outer plate, or as a separate graft, a strip of dense bone is taken, from which six or eight autogenous bone nails are made, of appropriate size. The strong outer plate is held to the flat surface of the bone, passing across the seat of fracture. Three or four drill holes are made through the graft and each fragment, into which the autogenous bone nails are driven. A square peg in a round hole secures firm attachment. In addition chromicized catgut sutures are passed about the bone and graft. The remainder of the endosteum is broken into small particles and placed with the "shavings" about the seat of fracture. If the graft is taken from the upper extremity of the tibia, it is often possible to obtain small pieces of spongy bone which are possibly more active in reproduction than dense bone.

With a limited number of femora and humeri a different technique has been used, which consists of cutting a long slot in each fragment, of about one-fourth inch in diameter, into which the dense outer portion of the massive graft is inserted across the line of fracture. After drilling about eight holes, bone nails are driven through the shaft of bone and graft. By these measures stabilization has been so complete that no motion between fragments can be detected—nevertheless external fixation is always applied.

In order to carry out this tedious procedure a team of trained associates is essential, as well as the most rigid instrumental technique. It is not a one-man operation. One surgeon with two associates, prepares the fracture, while the second and one assistant remove the graft and prepare the nails, otherwise too much time would be consumed.

External fixation remains for eight weeks; further observation might materially shorten this period. For six weeks some form of light brace, commensurate with joint function, is worn as experience has shown that all bone grafts require protection over a long period of time.

This method has been employed in 12 of the 17 ununited fractures of the humerus, with solid bony union and restoration of function in all cases. In other portions of the skeletal system the results have been highly satisfactory. In consequence the percentage of failures in operations for non-union in fractures has been materially reduced as compared with former methods.

THE NON-IMMOBILIZING ABDUCTION TREATMENT OF FRACTURES OF THE TUBEROSITY AND HEAD OF THE HUMERUS AND OF OTHER FORMS OF "SHOULDER DISABILITY"

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When of considerable extent and due to external violence (as a fall) fracture of the greater tuberosity of the humerus may be recognized by the local pain, tenderness, swelling, and ecchymosis. But fracture of this tuberosity may also be produced by the same type of mild or internal violence as causes subdeltoid bursitis, and can then be differentiated only by the roentgenogram; and here, too, the simulation is close, for to the inexperienced the shadow of the usually small bone fragment may much resemble that of a subbursal calcareous deposit (figures 1 and 2). That the signs and symptoms of subdeltoid bursitis are the same as those of fracture of the tuberosity is not surprising for the pathological anatomy is much the same in both: in one there is a tear of the supraspinatus near its insertion, in the other there is a tear through the bone at this insertion; in both there is an inflammatory reaction in, or possibly even a laceration of the floor of, the immediately overlying bursa.

All too commonly fracture of the tuberosity is treated by bandaging the arm to the chest—a vicious practice that invariably results in a stiffness of the shoulder that takes many weeks to overcome. The essential treatment is abduction—to relax the supra-

spinatus and the bursa, to approximate the fracture surfaces, and to obviate shortening of the adductor-rotators. If the fragment is large and shows a tendency to displacement when the arm is dependent the latter should be fixed in abduction of 90°-130°, and external rotation, in a plaster cast or on a splint. Jones[1] describes a method of holding the arm in outward rotation and abduction for tuberosity fracture "by putting a clove hitch round the wrist and passing the bandage behind the head under the opposite axilla, and by a firm spica bandage over the injured shoulder." In those few cases of complete tuberosity fracture in which there is much displacement that cannot be overcome by abduction, the fragment should be fastened in place by operation.

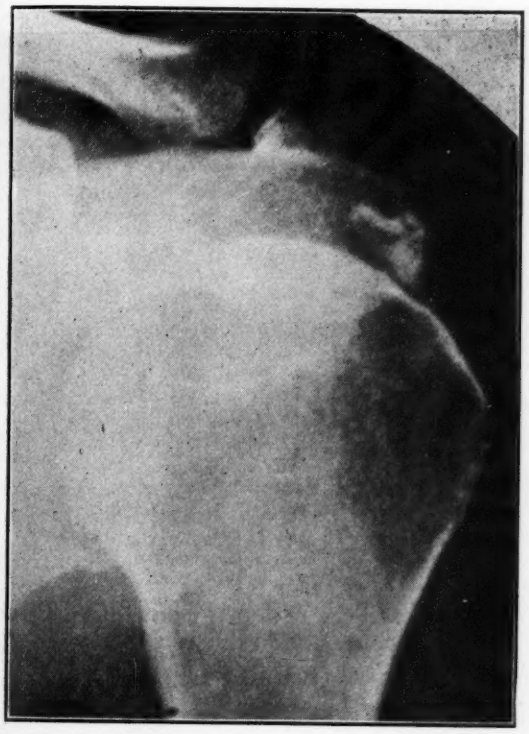

Fig. 1. Small lime deposit associated with subdeltoid bursitis, to be distinguished from fracture of the tuberosity.

The tuberosity fracture produced by internal violence is, however, usually a small fragment (from the superior facet) that shows little tendency to displacement, for it is attached to the supraspinatus tendon, the lateral portions of which are still attached to the humerus. For these, therefore, fixation in abduction is an unnecessary hardship. The simpler plan of treatment by the author's abduction method, described below, has proven more satisfactory.[2] As compared with fixation in abduction, it has the great advantage, among others, that it can be applied for an hour or two night and morning by the patient himself, who may go about his business during the day with his arm supported in a sling. Sometimes even a gross fracture of the tuberosity shows no tendency to displacement and may then also be treated by this method. Such was the case illustrated in figure 3, a complete fracture of the tuberosity through its base, produced by a fall. This patient, treated by the author's method, lost but two days from his business and, with the help of Indian club exercises, recovered with a painless, fully functioning shoulder.

In a large percentage of cases of fracture of the head or neck of the humerus there is little tendency to displacement after reduction and these, too, may advantageously be treated by this simple non-immobilizing abduction method either from the outset or after a fortnight of fixation-abduction.

Fig. 2. Small lime deposit associated with subdeltoid bursitis, to be distinguished from fracture of the tuberosity.

In the treatment of the various forms of "shoulder disability," with few exceptions, abduction is important; and failure to institute abduction and mobilization is in itself a cause of prolonging a shoulder disability—from shortening of the adductor-rotators and organization of periarthric exudate. Other writers on this subject also refer to the importance of abduction, but to secure it they resort to the employment of an abduction splint.

Where fixation in abduction is desirable (as in certain fracture cases or to secure, in infectious arthritis, ankylosis in optimum position) an abduction splint or plaster cast is indicated. But in the treatment of subdeltoid bursitis, tuberosity fracture (usually) and most of the other varieties of "stiff and painful shoulder" fixation is neither necessary nor desirable. For all of these the abduction splint has the following disadvantages:

It does not allow any play of motion in the joint, and thus it encourages muscle atrophy and shortening, organization of periarthric exudate and stiffness.

It cannot be applied, in acute cases, without pain or without narcosis.

It confines the patient to his home or the hospital.

It does not afford continuous, gradual increase of abduction. Each increase requires removal and readjustment by the surgeon.

It does not attain restoration of the full arc of abduction.

It holds the arm in partial internal rotation and does not secure external rotation.

It provides no means of intermitting the abduction when that position becomes uncomfortable or painful.

It is often painful and always very awkward.

Codman himself said that this method, which he applied in subdeltoid bursitis, "was a very arduous one for the surgeon, and caused a good deal of complaint from the patients," and that "the splint, in order to be comfortable, required frequent adjustments . . . ."[3]

Fig. 3. Gross fracture of the greater tuberosity of the humerus without displacement.

To obviate all the disadvantages of a splint, I devised several years ago a simple method of graduated, automatic abduction[4] which, slightly modified, has continued to give eminent satisfaction in the management of shoulder disabilities.

In bed, semi-recumbent on an incline made of three, four or five pillows, not too soft, the patient is told to abduct his affected arm, on the pillows, as far as he *comfortably* can. It will usually be noted that, relaxed in recumbency, his abduction is at once considerably more than when he was standing. Beneath the arm, thus comfortably abducted, a loop of surgical gauze or of a folded towel, is passed above the elbow, and fastened to a convenient place on the headpiece of the bed (figure 4). A small pillow is placed under the arm as an additional support. When external rotation is impaired, the hand will not drop back against the pillows and it may then be desirable to place a pad behind the forearm. If the head of the bed is raised it will increase the tendency for the patient to slide down. As his body little by little slides down in bed his arm travels relatively further and further up, and thus a shoulder that resists forcible efforts at abduction yields steadily to this gradual countertraction, which the patient often does not even feel. It is striking to observe that a person whose shoulder for months has not been abducted, actively or passively, beyond 45°, put thus to bed in the afternoon, may be found the next morning with his arm alongside his head!

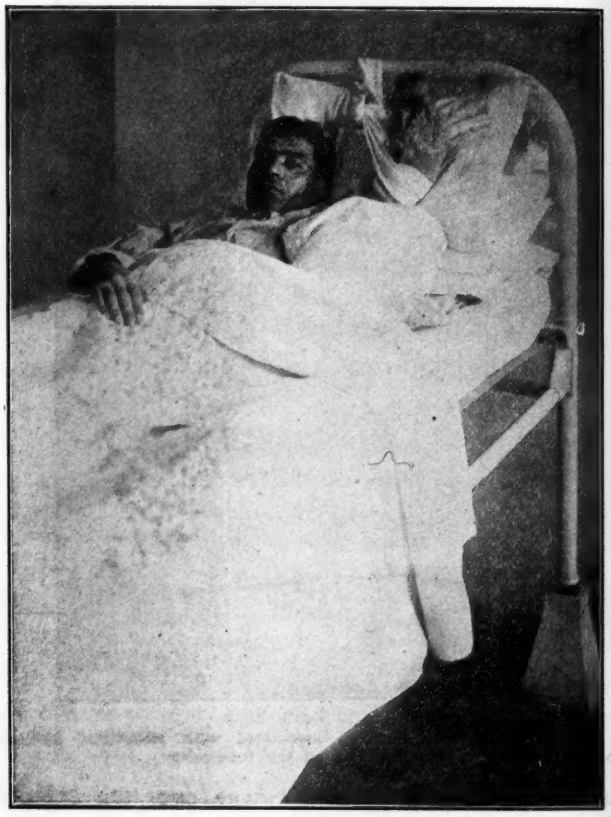

Fig. 4. The non-immoblizing method of securing abduction in the treatment of shoulder disability. Note the incline of pillows, the small pillow under the arm, the loop of gauze from the cross-bar of the bed and above the elbow, and elevation of the head of the bed.

A hot pad on the shoulder is soothing, and codein and acetylsalicylic acid ("aspirin") are helpful when there is pain. When the abduction position becomes irksome the patient may relieve it by pulling himself up on the pillows or by taking his arm out of the loop. Many patients cannot sleep with the arm thus raised; indeed, it is often desirable (except, for example, when thus treating a subluxation[5]) to intermit the abduction for longer or shorter intervals, for sleep, for meals, or for other reasons. In acute cases it is advisable that the treatment should be fairly continuous, but in milder or more chronic cases it may, instead, after a day or two, or from the onset, be employed for only a couple of hours night and morning, thus allowing the patient to attend to his business during the day.

It will be seen that the method lends itself to regulation by the patient himself and needs little attention from the surgeon. As the arm moves up, the sling is to be shortened or shifted accordingly. Sometimes it is desirable to loop the sling or an additional sling about the wrist which will also increase external rotation. In suitable cases, free from spasm, a sling may be passed over the cross-bar and carried down to the opposite hand, the patient amusing himself by pulling upon it from time to time. Other adaptations will suggest themselves, e. g., a back-rest may be substituted for some of the pillows and a couch or Morris chair (though less satisfactory) for the bed.

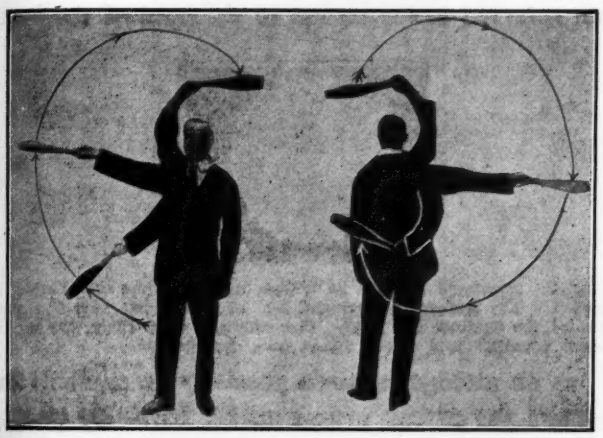

Fig. 5. Indian club exercise to increase or maintain abduction and to restore external and internal rotation.

In cases of subdeltoid bursitis full abduction may be thus secured in from one to seven days; it seldom takes longer. Once attained, the treatment should for a while, at least, be continued for a brief period each day; the sling will not then be required, probably, but the patient should recline for an hour or so with his forearm above his head.

At this time internal rotation will still be affected. An Indian club exercise is then invoked to secure its restoration and to maintain abduction. This exercise (figure 5) is performed with a single *light* club (1½ lbs.), the patient standing before a mirror. Holding the club by his side, with the arm rotated out, it is *swung* (not lifted) up, briskly, but *not violently*, over the head, the forearm then coming down a little behind the head (external rotation). Then the club is carried back through the same arc and up as far as possible behind the back. With internal rotation unimpaired one should be able with the arm behind the back to put the finger tips over the lower angle of the opposite scapula; and the patient should be encouraged to persist in the Indian club exercise until he can accomplish this.

The mirror is desirable to correct the tendency to swing the arm forward. *The movement is to be carried out in the frontal plane* of the body, i. e., parallel with the wall the patient is directly facing.

It is important, too, that the exercise should be neither violent nor long-continued, and it should be stopped at once if there is much pain. Either pain or fatigue may spell relapse of the shoulder into an irritative and spastic state. Swinging the club up and down two or three times, twice daily, is enough at the outset, and an increase to twelve times twice or thrice daily is a sufficient maximum.

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FRACTURE OF THE HEAD OF THE RADIUS

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For clinical purposes we classify these important fractures of the head of the radius as follows:

I—Complete

(a) Partial or marginal, one or more fragments dislocated out of position.

(b) Total—including comminutions or crushings with deformity of the head.

II—Incomplete

Comprising fissures which extend usually into the neck, the fragments remaining more or less in contact.

These fractures are generally found in adult life, males being afflicted about seven times as often as females in my experience. On the other hand, fractures of the neck of the radius are found in adolescents between the ages of 8 and 11 years and have a separate classification, a discussion of which will not be attempted in this article.

Along with fracture of the head of the radius occur several different associated bone lesions, many of which may be overlooked in a casual physical examination after forearm injury; or, vice versa, the associated lesion may be magnified into prime importance and even when a roentgenogram is made the all-important fracture of the radial head is overlooked. It behooves us, then, to think of radial head fracture in all forearm lesions. Frequently it is recalled to mind quite late after an injury of the forearm when the medical attendant finds, much to his surprise, that the bone lesion he treated seems to be healed

and yet the elbow joint fails to work properly.

These associated lesions in the order of their occurrence comprise:

1—Fracture of the upper shaft of the ulna.

2—Fracture of the coronoid or olecranon process or both.

3—Fracture of the lower end of the humerus.

4—Fracture of the radius at any level.

5—Dislocation of the head of the radius.

6—Dislocation of both forearm bones.

Fig. 1. Lateral view of elbow fracture involving the olecranon and head of the radius. One might easily overlook the important radius fracture which is marginal, complete, with dislocation of the broken-off fragment.

A fair retention of the normal configuration of the radial head is essential to the function of the elbow joint. Even a brief inspection of the superior radio-ulnar articulation demonstrates the great rotary range of motion which permits pronation and supination of the forearm. For this motion the radial head must be perfectly round, to fit into the radial notch of the ulna, where it is held by the annular and capular ligaments.

In almost any fracture of the radial head in adults except perhaps in faint fissures or incomplete fractures, the shape of the radial head is changed. A broken off marginal fragment may be extruded through the capsular ligament or may be forced down into the elbow joint cavity to block elbow motions by its presence. Crushed and comminuted heads lose their normal circular outline and will consequently not rotate completely in the ulnar notch. When callus is thrown out the head is further thickened, deformed, made adherent to the close fitting ligamentous structures and pronation and supination of the forearm are lost. As joint motion is restricted the capsule shrinks and interferes further with the full use of the elbow. The associated lesions, especially fractures of the ulna and humerus, may complicate the situation and lead to increased joint stiffness.

Symptoms: After fresh isolated fracture of the radial head the patient appears holding his injured forearm in his well hand, usually in a position of about 90° flexion. This attitude is quite common to all elbow injuries. It is a characteristic feature of radial head fractures that the patient can actively flex and extend the forearm nearly the normal range quite freely and painlessly. Swelling about the elbow joint and ecchymoses are usually delayed, the latter not appearing for two or more days. However, the fracture can be diagnosed by the fact that the patient will not wish to pronate or supinate his forearm, particularly because the latter motion causes severe pain referred to the region of the head of the bone.

Fig. 2. Specimen of head of radius removed from case shown in figure 1. The broken-off fragment has been replaced near the main mass of the head of the bone. One can see what distortion of the normal rounded head would follow bony healing.

When an attempt is made passively to supinate the forearm the patient complains bitterly. By placing thumb pressure directly over the head an area of exquisite tenderness is found, and when a finger is held there while the forearm is passively rotated, crepitus may be felt. However, crepitus is the most unreliable symptom; its absence means nothing against diagnosis of fracture.

The course of these injuries is one of progressive loss of function. At first pronation and supination are restricted; swelling and ecchymoses follow with additional loss of rotatory motion. Increasing pain and, ultimately, restriction of flexion and extension follow. Neglected injuries of this bone head frequently lead to elbow ankylosis.

Treatment: Non-operative treatment is indicated in adolescents and children with fracture of the neck of the radius, even if decapitation of the bone has resulted from the fracture. By direct pressure the loosened fragment may be forced into something approaching a normal relation with the rest of the bone and the forearm can then be swung up and splinted in a position of complete flexion. After 12 or 14 days active motions are begun with especial attention to an attempt to re-establish pronation and supination. Baking, massage and electrical treatments are strongly indicated. A happy functional result, with some loss of range of motion, may be anticipated in most cases.

For adults, unless the lesion is a mere crack, there

is no doubt that removal of the head is primarily indicated. The earlier this is performed after diagnosis the better the functional return. The removal of the fractured head with all displaced and loosened fragments insures against a mechanical blocking of the elbow joint and the sooner the operation is done, the less complication by intra-articular adhesions, joint shrinkage and restriction of motion will result.

Fig. 3. Fracture of the ulnar shaft with fracture and rotation of fragment of the head of the radius. A casual observer would have his attention distracted by the ulnar fracture and miss the important intracapsular fracture of the radial head.

We follow these rules:

(1) Remove all broken and fragmented pieces, no matter where they lie in the joint.

(2) Remove enough bone to insure freedom of all elbow joint motions.

(3) Avoid undue injury to the joint fibrous and synovial capsules.

(4) Be sure to leave the annular ligament intact—it is the greatest help in preserving joint contour.

(5) Spare the radial nerve and the insertion of the biceps tendon.

(6) Close the joint snugly.

A position of flexion and full supination is maintained by means of a posterior splint of moulded plaster of Paris for 5 to 8 days. All splintage is then removed and active movements are encouraged in an increasing range. After the skin stitches are removed hydrotherapy is used and the results are uniformly good after three or four weeks. Inside of two months the disability becomes minimal. Operation is of great help in long-standing fracture of the radial head, but the happy results are not so easily nor so quickly obtained. Arthroplasties are frequently required. Efforts at breaking up adhesions under anesthesia in unrecognized fractures of this sort simply increase disability and joint stiffness.

AN UNUSUAL DEFORMITY SEQUENTIAL TO A BURN OF THE HAND.

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Our attention has recently been called to the report by Gessner (*New Orleans Med. and Surg. Journal*, 1903-4, **56**, 445) of a case wherein the external genitalia of a negro boy was hidden by an apron of scar tissue from a burn. This curious condition impels us to report a somewhat similar instance of the burial of an organ by the resultant scar tissue of a burn:

J. G., age 45 years, negro. When four years of age, he fell into an open fire, severely burning both hands. They were bandaged immediately by relatives. No precautions were taken to insure absence of contractures; consequently when the bandages were finally removed, both hands were severely deformed. The burn of the right hand amputated all four fingers at the metacarpo-phalangeal joints. The left hand now presents an apparent absence of the thumb. ~~(See illustration).~~ No thumb is visible. A palmar scar extends over the thenar eminence. The thumb is buried beneath this scar, being adducted across the palm. The patient can slightly move the thumb under the scar. Within the last few years the thumb nail has grown so long that it pierces the skin at the base of the hand, in the sulcus between the thenar and hypothenar eminences. There is some inflammation around the nail. It is impossible to ascertain if the thumb retains its cutaneous covering. Operation is refused.

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New York City

ELMIRA, N. Y., JUNE, 1924.

VOLKMANN'S ISCHEMIC CONTRACTURE IN FOREARM AND ELBOW FRACTURES

The disastrously crippling condition of ischemic contracture-paralysis described a half century ago by von Volkmann is a degenerative process in the muscles, followed by fibrosis, and is due to interference with their blood supply. It may thus arise from the too protracted use of a tourniquet or, occasionally, from an arterial embolism. Much more commonly, however, it is seen as the unfortunate sequela of a fracture in the forearm or about the elbow and is then usually attributed to the too tight application of splints or, rather, to the application of splints and bandage not sufficiently loose to allow for the swelling in the parts that develops during the first twelve to twenty-four hours. And the dramatic and tragic feature of the condition is that the mischief is accomplished irretrievably within that short space of time. Indeed, the recognition of the possibility of the development of this and other serious troubles from interference with blood supply by the swelling of traumatized and sometimes bleeding tissues within too-snug splints and bandages has led many surgeons to adopt the rules never to apply a complete (unsplit) circular plaster cast in a fresh fracture case, to inspect all splinting apparatus within twenty-four hours whenever this is feasible, and to instruct the patient that, if the surgeon can not be reached, the dressing should be cut through or even removed, if the extremity beyond becomes cold, numb, blue or unduly swollen or if there is inordinate and increasing pain (Volkmann's contracture often develops painlessly, however). Especially must caution be employed and enjoined in treating fractures of the forearm and elbow. The acute flexion position so useful in certain types of elbow fracture, notably the supracondylar and trochlear, must be attained judiciously. If the elbow be immobilized in sharp flexion before the swelling has attained its maximum, indeed before it is subsiding, there is certainly invited the grave risk of serious trouble.

If a Volkmann's contracture develops after the application of a splint or bandage for fracture in the forearm or elbow is it, ipse facto, evidence that the dressing was too tight, is it presumptive evidence of unskilful treatment?

In the *Journal-Lancet,* April 15, 1924, discussing "The Commoner Deformities Following Fractures", Melvin Henderson of the Mayo Clinic states that he has seen several cases of Volkmann's ischemic paralysis in upper forearm fractures in which no bandage, cast or splint had been applied. And our text-books record that others have made the same observation.

DaCosta (Modern Surgery, 8th edition, p. 805) says: "The condition may come on after the application of an Esmarch band, after a severe injury in the neighborhood of the elbow joint, may follow ligation of the main artery of a limb, venous embolism, venous thrombosis from injury or infectious disease, Raynaud's disease or exposure to cold * * *"

Scudder (The Treatment of Fractures, 9th edition, p. 276): "Littlewood has emphasized the fact that a splint improperly applied is not the sole cause of the condition, for the contracture has followed where no splint has been worn. Tremendous swelling of the soft parts may cause local pressure upon the circulation."

Speed (Text-Book of Fractures and Dislocations, p. 69): "We believe now that the pressure may come not only from tight bandaging, splints, or casts, but also from pressure within the extremity caused by the extravasation of blood beneath resisting fascial envelopes. There are cases on record following fracture in which no splint or bandage of any kind was applied. Murphy, Collinson, and Jones have seen cases. Bardenheuer states that 8% of the cases follow fractures to which no dressing or attempts at reduction have been applied."

Baldwin (in Jones' Orthopedic Surgery of Injuries, Vol 1, p. 278): "The cases seen in civil life usually follow fracture or severe injury in the neigh-

borhood of the elbow-joint. Many of them give a history of tight splinting or of uneven application of too firm a bandage. Thus by pressure from without there is at least partial inhibition of arterial supply and a retardation of the venous return from the structures below the injured area. On the other hand, Sir Robert Jones states that pressure from within, resulting from hematoma and bruising of muscles by sharp bone fragments, is equally liable to be the causative factor." Since this work was edited by Sir Robert himself we may assume that in this last broad statement he was correctly quoted.

Whether we regard internal pressure from hemorrhage as causing Volkmann's contracture in only eight per cent of cases, as noted by Bardenheuer among those in which no bandage had been applied, or whether, with Jones, we believe that such internal pressure is "equally liable" with bandages and splints to produce the crippling myositis, it is clear that we are not justified in any case of Volkmann's contracture in assuming that the splint or bandage produced it; and, accordingly, we should be chary of suggesting or agreeing that the physician who applied the splint was unskilful.

ATTENUATED BONE INFECTIONS; SILENT FOCI OF LOCALIZED OSTEOMYELITIS

Under the apt title of "Silent Foci of Localized Osteomyelitis," Phemister of Chicago has reported (*Journal of the A. M. A.*, April 26, 1924) four striking illustrations of a condition concerning which he says:

> It is generally stated in the literature that the symptoms produced by minor foci of osteomyelitis may be slight, but I have found no statement to the effect that localized osteomyelitis (aside from a pocket about the root of a tooth) may begin silently and proceed to the stage of complete destruction of the bony area involved, with surrounding new bone formation, before there are any local symptoms whatsoever. This condition is rather astonishing when met with for the first time. It is apt to be found in patients in whom some focus of bone infection has remained active. The subsequent lesions may develop at any time, up to two or three years after the onset of the initial bone infection. There may be mild general symptoms in the absence of local symptoms, and the possibility of a silent focus should always be kept in mind when a patient with chronic pyogenic osteomyelitis presents the picture of a low grade infection, which is too severe to be explained by the findings at the seats of the known lesions. A recurrence at the site of a previous osteomyelitis may begin without local symptoms, and may proceed to the point of extensive absorption before pain is experienced.

In the cases he records there were numerous foci of localized bone destruction or of bone abscess, of which some had produced but mild symptoms and some were discovered only by roentgenography. That areas of bone destruction and suppuration may long exist without symptoms is not a new observation, however; the long "silent" chronic bone abscess with "surrounding new bone formation" is familiar to surgery.

Phemister's interesting study illustrates well what we discussed editorially (The JOURNAL, September, 1923) under the title of "Longevity of Pathogenic Bacteria in the Tissues; Attenuation of Bacterial Virulence; Chronic Bone Abscesses." It emphasizes the importance of recognizing residual and metastatic foci of osteomyelitis that may make their presence known many years after the storm of acute osteomyelitis or other infection has passed. And the clinical behavior of Phemister's cases may be interpreted as also well illustrating the attenuation of the virulence of the infecting organisms in these chronic circumscribed bone lesions. The importance of this is that such lesions may often be adequately dealt with by conservative types of operation, as contrasted with free osteotomy and prolonged open treatment. As we have repeatedly pointed out, the chronic bone abscess is usually sterile or nearly so, and may be cured by simple evacuation, under nitrous oxide narcosis, through a small drill hole, without leaving any drain in the bone. Indeed, as in Phemister's report, some foci of bone infection may recede and apparently go on to cure without operation. We are convinced, on clinical grounds, that even acuter grades of osteomyelitis sometimes recede spontaneously.

Phemister says of some of the bone cavities that they were filled with granulations, cultures from which were sterile. Concerning these, and those containing staphylococcus pus, he does not state, however, how he managed the operative wound—whether by free and prolonged drainage or not. It would be interesting to know whether he took advantage of the conception that these chronic foci are sterile or of attenuated virulence.

The study of chronic bone infections, to which this description of "silent foci" of localized osteomyelitis brings a vivid picture, is a fascinating one from many standpoints. Not the least of these are the consideration of longevity of organisms in the tissues and the attenuation of their virulence, and the opportunity that is afforded for the development of nice and conservatively planned operations.

"Ununited fracture is often the result of surgical impatience. Non-union would rarely occur if delayed union received proper attention."—SIR ROBERT JONES.

Progress in Surgery

Selections from Recent Literature

The Treatment of Fractures. D. P. D. WILKIE, Edinburgh. *The British Medical Journal*, April 26, 1924.

Operation should be reserved for the following classes of cases:

1. Those in which, owing to the interposition of soft parts, the fragments cannot be brought into close apposition.

2. Those in which repeated redisplacement occurs after reduction.

3. Certain fractures into joints in which a fragment cannot be controlled and interferes with joint function.

4. Cases of non-union of more than six months' duration.

The oblique fracture through one or other of the tuberosities of the tibia into the knee-joint is one of those for which operation with nailing is indicated. In fracture of both bones in the lower third of the leg, the tendency to malunion and non-union is such that many surgeons now treat all cases by operation, with or without the application of some internal splint. In this fracture reduction under an anesthetic with temporary fixation in plaster has much to commend it. If treated by splints—as by the box splint—elevation of the limb *without* flexion of the knee will be found a useful aid in preventing the forward projection of the lower end of the upper fragment of the tibia.

Wilkie lays emphasis on the following points:

1. In the case of most fractures it is necessary to *reduce* the fracture under a general anesthetic.

2. In upper limb fractures early active movement is desirable. (Fractures in the immediate vicinity of the elbow form an exception to this rule.)

3. In fracture of the lower limb restoration of the correct alignment and length of the limb takes precedence over all other considerations.

4. In certain fractures, notably Pott's fracture with partial dislocation, immediate fixation in plaster gives the safest assurance of a good result.

5. In compound fractures excision of the wound with primary suture should be attempted whenever possible.

The Early Treatment of Fractures. C. B. HEALD, England. *The British Medical Journal*, April 26, 1924.

Heald says that by the use of the anodal galvanic current for injuries or fractures more rapid relief of pain and swelling is secured, more complete muscular relaxation is obtained, and earlier return to useful function is possible, than by the more usually accepted methods.

Fractures of the Spinal Column. A Report of Fifty-two Cases. E. W. CLEARY, San Francisco. *California and Western Medicine*, May, 1924.

Cleary reports on 52 cases of fractures of the spinal column. These fractures are apparently more common than has been realized. In only 30% of these cases was the diagnosis made early. This he attributes to improper history taking and inadequate roentgen and physical examination.

Twenty-five of the 52 fractures were due to falls from a height ranging from 6 to 70 feet. Eighteen were due to heavy masses falling on the patient; 4 were due to heavy blows on the shoulder; 4 to heavy lifting and twisting strains. Deformities, limitation of motion, muscle spasm and discoloration of the skin are to be looked for best in the standing position. Rigidity of the injured segments and guarded motions of the body as a whole are characteristic symptoms. In the treatment rest is essential. This may be secured by head traction, special fracture beds, collars, plaster jackets and other devices. The author considers the Hibbs better than the Albee operation, but has devised an operation which combines features of both. His operation, illustrated in the article, consists in a splitting of the spinous processes of the vertebrae with two lateral laminotomy extensions. Into these lateral laminal clefts a wedge-shaped graft is laid on each side and over these the divided spinous processes are folded. Following his fusion operation the patient remains in a plaster jacket on a Bradford frame for seven to eight weeks and then wears a modified Taylor brace for at least four months while gradually increasing the range of action. After thorough fusion industrial patients return to work in eight months to a year. There were reported by the California State Industrial Commission about 30-40% of cases with total disability. Conservatively treated cases have a period of convalescence approximately twice as long and a disability of 40 to 50%. No cases of fractured spine treated conservatively should be immobilized less than eight to twelve weeks, and in severe cases six to eight months are necessary.

Surgical Treatment of Fractures of Both Bones of the Forearm. (*Le traitment chirurgical des fractures des deux os de 'l avant bras*). L. COURTY, Lille. *Archives Franco-Belge de Chirurgie*, February, 1924.

Courty reports three cases of fracture of both bones of the forearm. Reduction of such fractures even under the fluoroscope is often impossible. He considers such fractures as indications for open operation. He uses Lane plates with excellent anatomical and functional results. The ulna is plated first through an incision along the crest of the ulna. The radius is then operated upon through a postero-external incision.

Low Radio-Cubital Impaction. Resection of the Callus and Osteosynthesis. (*Syntose radio-cubitale inférieure. Resection du cal et osteosynthese. Guerison.*) LEJEMTEL. *Archives Franco-Belges de Chirurgie*, February, 1924.

Le Jemtel's patient, a mechanic, aged seventeen, was struck directly on the wrist by a tool falling a distance of one meter. The fracture was apparently reduced and put in a cast. The functional result, however, was unsatisfactory and *x*-ray examination one month later showed a separation of the ulnar epiphysis with an impaction of the lower end of the ulnar into the radius. A Lane plating operation with resection of the callus was performed. Complete cure resulted.

Late Ulnar Nerve Palsy Following Elbow Fracture in the Adult. WALTER M. BRICKNER, New York. *The Journal of Bone and Joint Surgery*, April, 1924.

Fracture of the external condyle of the humerus in childhood with resulting cubitus valgus has become recognized as the typical injury which three, four, five, or twenty or thirty years later, may be followed by the appearance of an ulnar neuritis or paralysis. However, the phenomenon of late ulnar nerve palsy is not always the result only of elbow fractures in childhood, nor, indeed, only of fractures. Brickner reports a woman who at the age of 52 sustained a fracture of the tip of the olecranon. One year later she developed paralysis of the ulnar nerve. This was liberated from its bed of scar tissue and transplanted anteriorly. Cure followed.

The Treatment in Forced Adduction of Recent Bimalleolar Fractures. (*L'appareillage des fractures bimalleolaire recentes en adduction forcé*). M. SAVARIAUD. *La Presse Medicale*, April 30, 1924.

Bimalleolar fractures of the ankle with no displacement of fragments are treated by rest, massage and immediate mobilization. Walking is interdicted for a period of twenty-five to thirty days. In males with slight displacement of the fragments, he uses the side pieces recommended by Delbet to avoid production of deformity. Most cases, however, show a marked external displacement. Such cases are put up in an overcorrected adducted position. His general rule is to overcorrect in a direction opposite to that occupied by the foot. If treated early practically the only obstruction to gentle manipulative reduction will be muscular spasm which is best controlled by an anesthetic. In his opinion, spinal anesthesia is the method of choice. The fractures are then put into plaster for a minimum of twenty-five to thirty days. Poor results are due in general to tardy reduction, faulty technic or insufficient attention on the part of the surgeon.

The Orthopedic Problem of Resection of the Knee (*Le probléme orthopedique de la resection du Genou*). CALVE and GALLAND, Berck. *La Presse Medicale*, April 9, 1924.

The problem in knee resection consists first in obtaining

exactly similar apposing bone surfaces and second in being able to regulate and correct the position of the leg in relation to the femur. The authors solve the first problem by the use of a double-bladed saw which gives them almost mathematically corresponding bone surfaces. The second problem is solved by the use of an ingenious apparatus incorporated prior to operation in a bivalved plaster spica reaching to the toes. At the level of the knee the cast is cut away, leaving the two parts of the cast connected only by the apparatus. By means of a simple slot and pivot arrangement the leg can be put into any conceivable position and even translated as a whole in relation to the femur.

Note on a Possible Sequela After Operation for the Removal of the Internal Semilunar Cartilage. NAUGHTON DUNN, Birmingham, England. *The Journal of Bone and Joint Surgery*, April, 1924.

The patellar branch of the internal saphenous nerve is divided by the usual incision made for removal of the internal meniscus of the knee joint. In a small percentage of cases a painful neuroma may form in the scar and give rise to a sensation of pain as it passes over the margin of the condyle on flexion of the joint. The author has seen 8 cases. Excision of the scar and evulsion of the nerve is the most satisfactory treatment.

Microscopically Proved Sarcoma of the Humerus. HARRY H. BOWING, Mayo Clinic, Rochester, Minn. *The Surgical Clinics of North America*, April, 1924.

The case reported here was first diagnosed medium round-cell sarcoma, and following radium and *x*-ray treatments, was diagnosed mixed-cell sarcoma. Differentiation is a possibility, and is produced chiefly through the action of the therapeutic rays. The case is reported in detail, as a proved instance of sarcoma of the humerus, the patient living three years after the first operation. His general condition is excellent thus far. The therapeutic procedure was a combination of radium, roentgen ray, amputation.

On the Incidence of the Sacralized Transverse Process and Its Significance. SHERWOOD MOORE, St. Louis, Mo. *Radiology*, May, 1924.

Sacralization of the transverse process of the fifth lumbar vertebra is congenital and is the taking on of sacral characteristics by the process. The term should be restricted to designate only such deviation. Simple increase in length, bulk and the approximation of the shadows of the transverse process and those of the sacral alæ do not constitute sacralization. Radiographically, the last may be produced by the projection of the images of the transverse process by the angle of incidence of the rays, due to the latter not being perpendicular to the anterior surface of the fifth lumbar vertebra. It is also possible that, due to the position of the fifth lumbar vertebra upon the sacrum, the angle of the former on the latter does not permit a perpendicular incidence of the ray on the anterior aspect of the vertebra in question. The result in either case is the production of an apparent impingement of the process on the sacrum.

Simple increase in length should not be confused with sacralization, as any degree of the latter can be placed in the category of normal variation.

With the foregoing definition of sacralization, its presence should be conditioned radiographically by the following:

1. The upper and a varying proportion of the outer border of the sacralized process should have the form, outline and dimensions approximately those of a normal fifth process; in unilateral cases this is readily seen.
2. The sacralized process must be manifest as an increase in size which originates from its inferior surface.
3. This mass of bone must extend downward and outward.
4. A certain small portion of the root of the process which shows no enlargement must remain, equaling the dimension of the canal for the fifth lumbar nerve.

Many of the illustrations found in the literature are not sacralizations at all.

The series of cases of sacralization which the writer has assembled numbers 117. These 117 cases were found in 3,640 plates of the lumbo-sacral region, which gives a percentage of occurence of 3.2 as compared with 4% reported by Albanese.

The number of lumbar vertebræ could not be determined in 33.9% of cases; in 44% there were five and in 20% six rib-free pre-sacrals. Twenty-three per cent of cases were right sacralizations and 40 were left; the bilateral sacralizations appeared in 34%.

and 40 were left; the bilateral sacralizations appeared in 34%.

The anomaly was discovered adventitiously in 32% of cases, whereas the patients had back or nerve symptoms in 61% of all cases studied.

Fifty-nine per cent of all cases followed occupations that subjected them to back strain and 26.8% had suffered actual injury.

Back pain was the chief complaint of 61% of the patients radiographed; 56.8% of the total number of cases had lumbar pain, while 35% had referred pains and 28% tenderness on palpation.

The symptoms found in sacralization fall into two groups: nerve and joint. There are also combinations of the two. In no case can sacralization be diagnosed on symptoms where existent, or on physical examination because of the protean nature of the manifestations.

The theory that the pain is due to the impingement of bony parts or the compression of soft structures between bony parts seems not to have a leg to stand on. Resection promises a great deal in selected cases. The individual with a sacralization has a liability and should follow an occupation free from the hazard of back strain.

Novocain Treatment of Muscular Atrophy after Injuries. (*Novocainbehandlung der Muskelatrophie nach Verletzungen*). F. MANDL, Vienna. *Archiv für klinische Chirurgie*, April 7, 1924.

Increased muscle tonus such as occurs after injury, particularly as in the case of fracture, leads to muscle atrophy. Novocain injection by stopping the muscle tonus will prevent muscle atrophy. This is of great practical importance in cases of fracture, following which there is usually marked atrophy with interference in work and play.

The prophylaxis and treatment of muscle atrophy has previously consisted of motion and has not been complete. The action of the injection (20 to 30 c.c. of a ½% novocain solution) by nerve blockade lasts 6 to 8 hours, is repeated at daily intervals for several days, and having once overcome the initial spasm, seems to have a permanent effect. The muscle at complete rest does not undergo atrophy.

Late Results of the Surgical Treatment of Chronic Lymphatic Edemas. (*Les résultats eloignes du traitment chirurgical des uedemes lymphatiques chroniques*). E. KONDOLEON, Athens. *Archives Franco-Belges de Chirurgie*, February, 1924.

Kondoleon reviews a number of cases operated upon by his procedure by other surgeons, and 20 patients operated upon by himself since 1912. He comes to the conclusion that a permanent and complete cure is not affected by his operation, but that there occurs a noticeable reduction in the size of the limb with a marked improvement in function. He thinks his results are due to the formation of new lymphatic passages from the subcutaneous tissues through the muscles.

The Results of Surgery for Migraine. J. ARTHUR BUCHANAN, Pueblo, Colo. *Surgery, Gynecology and Obstetrics*, May, 1924.

The histories of two patients are presented to illustrate the end-results of surgery for migraine. Nasal operations, etc., and assaults to destroy foci of infection in the teeth, tonsils, gall-bladder, appendix, and so forth, are all valueless. Migraine is hereditary in man and is transmitted from generation to generation according to the laws of Mendel. Surgical procedures have no place in the therapy for migraine.

The Continued Intravenous "Drip": With Remarks on the Value of Continued Gastric Drainage and Irrigation by Nasal Intubation with a Gastroduodenal Tube (Jutte) in Surgical Practice. RUDOLPH MATAS, New Orleans, La. *Annals of Surgery*, May, 1924.

Apart from its many uses as a gastric drain, irrigator and flue (for gases), the Jutte tube, introduced through the nose and allowed to remain permanently in the stomach, is also valuable in other surgical conditions of impoverished nutrition and exhaustion in which the early instillation of nutrient

fluids directly into the intestines is indicated. A notable example of such an indication is afforded by advanced cases of pyloric obstruction from benign or malignant stricture, for which a late gastrojejunostomy is performed in conditions of long fasting or marasmus. In such cases it has been Matas' practice, while performing a gastroenterostomy, to introduce a duodenal tube, previously inserted through the nose, into the jejunum for a distance of 10 to 12 cm. through the newly created stoma, where it is allowed to remain after the gastroenterostomy has been completed and until the normal gastric functions have been resumed. The tube thus introduced into the jejunum is utilized immediately or shortly after the operation as a transgastric jejunal drip, which supplies a peptonized glucose solution in a far more certain way than when this is administered by the usual rectal drip.

For certainty of dosage, promptness and duration of effect in sustaining a weak or failing circulation none of the methods of cardiovascular stimulation at present in vogue for surgical conditions can compare with the continuous intravenous drip. When glucose is made the basis of the infused fluid, the continued intravenous drip is incomparably superior to all the other methods of parenteral nutritution and medication, as it supplies continuously an easily assimilated foodstuff in isotonic solution for an indefinite time.

Torsion of an Appendix Epiploica Simulating an Attack of Acute Appendicitis. FRANK HELVESTINE, JR., University, Va. *Virginia Medical Monthly*, May, 1924.

Helvestine records a case, and says:

Torsion of appendices epiploicae are probably not so rare as the few reports in the literature would indicate. The majority of abdominal operations are performed for appendicitis and the usual operation is done through a small McBurney incision, which permits of little exploration of the abdominal cavity. In a certain number of cases which are operated upon with a diagnosis of appendicitis, slight or no pathological changes are found in the appendix, certainly not sufficient pathology to account for the symptoms of which the patients complain. Yet the appendix is removed and the patients have no further trouble. These cases may very easily have as the cause of the symptoms an appendix epiploica with a twisted pedicle. With gangrene of these bodies, pain subsides and either absorption or calcification results.

In abdominal surgery it is well to keep the appendices epiploicae and their pathology in mind, and, when no gross changes can be demonstrated in the suspected viscera, it is well to explore the colon for disease of these fatty bodies, and not relegate these cases to the class in which there is nothing abnormal found.

The Participation of the Liver Parenchyma in Gallstone Disease. (*Die Beteiligung des Leberparenchyms an der Gallensteinkrankheit*). A. TIETZE and K. WINKLER, Breslau. *Archiv für klinische Chirurgie*, April 7, 1924.

An inflammatory process at the various points of exit of bile from the liver and ducts frequently is not without effect upon the liver parenchyma, and, indeed, more frequently and more extensively than previous experience has shown. The appearance of the liver at laparotomy gives no indication of the underlying pathological condition. Microscopic examination shows that the bile producing cells, with few exceptions, not only are included in the infection, but also show definite and often degenerative injury. The affection is not only of the parenchyma, but of the connective tissue as well. The study was made of small pieces of material removed at operation.

Gastrointestinal Symptoms and Epigastric Hernia. LEIGH F. WATSON, Chicago. *Medical Journal and Record*, April 16, 1924.

Hernia in the linea alba has often been confused with gastric or duodenal ulcer, and sometimes the two conditions coexist. The presence of a tumor or a slitlike opening in the linea alba, with or without the protrusion of a small mass on coughing, will help to establish a diagnosis of hernia. In gastric ulcer there is a localized point of tenderness in the linea alba, as is always found in hernia. In ulcer the symptoms come on at a certain interval after eating, while in hernia the paroxysmal attacks have no relation to meals but usually follow physical exertion, and the patient finds that the most relief is secured by assuming a doubled up position, which relaxes the linea alba. In hernia, relief is sometimes secured by lying on the back; and in ulcer, by lying on the right side.

Tuberculomas of the Bowel. PHILLIP W. BROWN, Mayo Clinic, Rochester, Minn. *The Surgical Clinics of North America*, April, 1924.

Tuberculomas of the intestinal tract are localized manifestations of tuberculosis and, by virtue of being localized, present a difficult problem in the differential diagnosis.

The average age and duration of symptoms are among the more important features in distinguishing tuberculoma from carcinoma, but the impossibility of making a definite diagnosis had been illustrated in several cases, particularly in older people.

Primary intestinal tuberculosis may occur, and 30 per cent. of the patients in this series of 32 cases seem to belong to this group. The lesions may arise from infection conveyed by tuberculous meat and milk, which emphasized the necessity of more rigorous extermination of bovine tuberculosis. The ileocecal tuberculomas offer a favorable opportunity for operative procedures. When there are also lesions in the small bowel, or if the lesions are confined to the small bowel, the chances for cure by surgical measures are much less.

The advisability of exploration often depends on the presence and extent of tuberculosis elsewhere. In certain cases surgery becomes urgent because of obstructive symptoms.

Neo-arsphenamin was tried in two patients with tuberculomas of the small bowel. Apparently complete recovery occurred in one in which hygienic measures were also followed in the West. In the other patient there was no appreciable change in the condition.

A tumor in the ileocecal region should not be considered malignant, and surgical procedures should not be discontinued until the type of tumor has been determined microscopically.

Carbuncle and Its Treatment by Magnesium Sulphate. ALBERT E. MORISON, England. *The British Medical Journal*, April 19, 1924.

Morison treated 28 cases of carbuncle by applying to the whole of the inflamed area a paste of magnesium sulphate.

With 1.5 lb. of dried magnesium sulphate are mixed 11 oz. of glycerin. The dried magnesium sulphate is in the form of a fine white powder which contains 12% less water than the ordinary commercial Epsom salts. The glycerin is put in a hot mortar and the sulphate added, slowly stirring and mixing with a warm pestle all the time. The result is a thick white cream, so hygroscopic that if exposed to the air it rapidly absorbs moisture and becomes fluid. It must therefore be preserved in a covered jar.

The paste is spread thickly on a piece of sterile white lint sufficiently large to cover the whole of the inflamed area. A piece of jaconet is put over the lint to cover it entirely, and cotton-wool in abundance over and around the part. A profuse discharge of serum takes place, and the dressing is left unchanged for 12 or 24 hours and then renewed. Within a few days the central slough separates and a raw granulating surface is left. The relief to the patient after one or two applications is very great. Pain is abated, constitutional disturbances disappear, and sleep comes naturally.

As soon as the slough has separated the crateriform ulcer is dressed with the paste until all signs of sphacelating cellular tissue have disappeared and a healthy granulating surface is seen. The cavity is then packed daily and the undermined edges supported with strips of lint about 1½ in. wide, wrung loosely out of a saturated solution of magnesium sulphate made by dissolving 40 oz. in 30 oz. of boiling water and 10 oz. of glycerin and sterilizing in an autoclave. The whole area is then covered with a double layer of lint saturated with the solution, over which a piece of jaconet and then cotton-wool is placed, and fixed loosely by a bandage.